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A QUARTERLY MISCELLANY OF
ENTERTAINING AND INSTRUCTIVE ARTICLES ON
SCIENTIFIC SUBJECTS.

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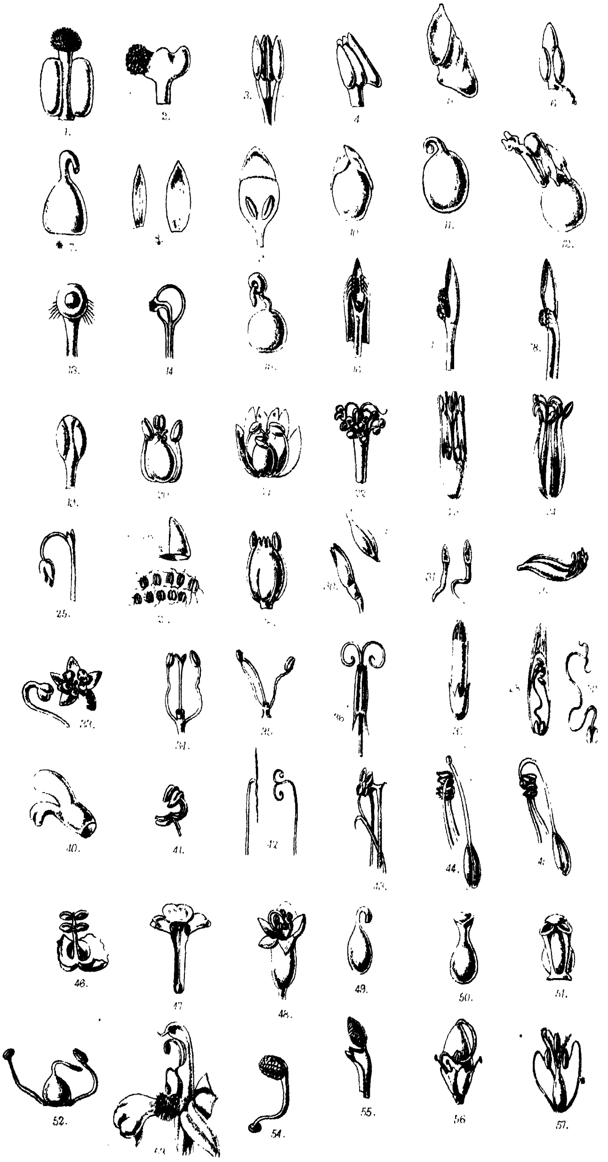


POPULAR SCIENCE REVIEW.

THE SELF-FERTILISATION OF PLANTS.*

BY THE REV. GEORGE HENSLOW, M.A., F.L.S., F.G.S.

[PLATE I.]

WHEN the discovery that plants had sexes became a well-recognised fact, the relative position of the stamens and pistil in a flower was noticed as peculiarly favouring, as was supposed, their union; and in accordance with the teleological views of the last century, the oft-quoted generalisation was made (attributed, I believe, originally to Linnæus), that whether a flower be pendulous or erect, the stigma was always *below* the anthers, so that the pollen might *fall* upon it, self-fertilisation being thus supposed to be the object in nature.

It is worth while pointing out some objections to this idea. In the first place, if nature intended the pollen to reach the stigma, why, it may be asked, is it allowed to *fall*, as it would be applied to it with much more certainty if the anthers were placed in close contact with that organ, as is actually the case in all really self-fertilising plants, so that there would be no chance of the pollen being blown away by the wind before it could fall down upon the stigma. Secondly, how comes it that flowers are monœcious and diœcious, that is, with their sexes separate, either in different flowers on the same or on distinct plants, respectively? Thirdly, many flowers, though possessing both stamens and pistil, are dichogamous, that is, the anthers mature and shed their pollen before the stigma is ready to receive it; or else the stigma matures before the anthers. Lastly, a large proportion of conspicuous flowers are irregular or else

* The subject of a paper by the present writer in the "Transactions of the Linnæan Society," to be published in the ensuing volume.

highly attractive to insects, and, as has been shown by Sprengel in 1790, and by various botanists at the present day, are specially adapted to insects who transfer the pollen from one flower to another.

The effects of the last-mentioned process have been ascertained and described by Mr. Darwin in his work on "Cross and Self-Fertilisation of Plants." He proved, by experiments, that when ordinary garden plants are crossed by others of the same stock, or by others of a different stock of the same species, the offspring generally showed greater vegetative vigour in growing taller and in bearing more vigorous and greener foliage; while in their reproductive organs there was brighter and greater variation in colour, and often more seed was set than when such plants had been continuously self-fertilised.

The results would seem, therefore, to exactly fulfil an inference which the late Dean Herbert drew from his experiments with bulbous plants, and which he has recorded in his work on the *Amaryllideæ* (p. 70), as follows:—"I am inclined to think I have derived advantage from impregnating the flowers from which I wish to obtain seeds, from individuals of another variety or another flower, rather than its own, and especially of any grown in different soil or aspect."

A very considerable amount of literature now exists on the subject of cross fertilisation by insect agency. The beautiful and exquisite adaptations exhibited by so many conspicuous flowers have attracted the attention of observers, so that whoever sets to work to examine flowers with this object in view, is pretty sure of making new discoveries of special adaptations.

So obvious, then, has the importance of insect agency been thought to be, that the inference has been drawn that cross fertilisation is necessary for flowers; and Mr. Darwin generalised this inference into an aphorism, which may be regarded as expressing the exactly opposite view to that attributed to Linnæus. namely, that "Nature abhors perpetual self-fertilisation." We may contrast these opposite poles of thought, somewhat as follows:—With Linnæus, Nature had specially designed (most?) flowers to secure self-fertilisation. With Darwin, Nature has specially adapted (most?) flowers to avoid self-fertilisation.

I add "most?" because these observers do not fail to see that there are exceptions in both cases.

Opinions have often been compared to a pendulum, whether they be political, ecclesiastical, or otherwise, in that for a time they run high in one direction; but a reaction sets in and down they go, and are then carried up to the opposite extreme. It is not till both extreme forms have been well tested that at last the excesses in both are struck off, and the truth which invariably underlies each is at last recognised, and the "golden mean" is

then permanently secured in their combination, and the pendulum comes to rest.

Such I believe to be the case with the question before us; for I think I can show that Darwin's aphorism is wrong in its extreme form, if not altogether; and the object of the present paper is to endeavour to combine the twin truths which underlie the cross and self-fertilisation of plants.

Mr. Darwin's works have gone far to strengthen the belief that intercrossing is absolutely necessary for plants; and that if self-fertilisation be continued for lengthened periods the plant tends to degenerate and thence to ultimate extinction. This I believe to be absolutely false. Indeed, so strong is the general belief in the value of intercrossing, that self-fertilisation is kept quite in the background, if at all alluded to, by writers on this subject; so that flowers are now usually classed either as "entomophilous," *i.e.*, adapted to insect agency, or else as "anemophilous" or wind-fertilised.

When Mr. Darwin examined Orchids and wrote his excellent book on their fertilisation, he was struck with the singular exception of the "Bee-orchis" (*Ophrys apifera*), which is so constructed as to fertilise itself; and yet this plant is one of the most abundant of orchids, a vigorous grower, and shows no signs of degeneracy at present. Another case, amongst many others mentioned in his "Cross and Self-fertilisation of Plants," is that of the garden pea, which is constantly self-fertilised in this country, and yet the papilionaceous corolla is manifestly and specially adapted to insects. Mr. Darwin alludes to Mr. A. Knight's varieties, originally obtained by crossing, as having lasted for upwards of sixty years, by self-fertilisation alone; and the inference in both cases is, that the effects of crossing—in the ancestral form of the Bee-orchis, which doubtless required it, and in the artificial crossings made by Mr. Knight—have lasted, to the present day in the first case, and for sixty years in that of the pea.

Moreover, since a great number of plants are now discovered to be in the habit of setting seed, and that too very freely, without insect aid, a further generalisation has been made, that not only were they originally crossed, and the good effects have lasted till now, that is to say, for practically an indefinite series of ages; but that they *must* be occasionally crossed again, or they will inevitably die out in time.

Now it must be carefully noted that these generalisations are entirely subjective or *à priori* inferences, based upon the *assumed* necessity of crossing; that assumption being itself based upon the vast number of adaptations to insect agency which exist; but the fact that self-fertilisation is really of wider extent in the vegetable kingdom is ignored. On the other hand, the belief appears to be generally held that many flowers

are specially adapted ("purposed") to prevent self-fertilisation. This I am convinced is an erroneous assumption.

Researches into the structure of flowers have led me to draw the following conclusions:—*

1. *The majority of flowering plants can, and probably do, fertilise themselves.* Independently of arriving at this conclusion from a study of nature, I infer it from Mr. Darwin's results: for he protected a number of plants from insects, and gives two lists of forty-nine species in each, the one of plants more or less self-fertile, and the other self-sterile without insect aid; but he adds:—"I do not, however, believe that if all known plants were tried in the same manner, half would be found to be sterile within the specified limits." †

2. *Very few plants are known to be physiologically self-sterile* when the pollen of a flower is placed on the stigma of the same flower. The genus *Oncidium* is a remarkable instance, the pollen of some species having even a poisonous action on the stigma.‡ *Linum*, as Mr. Darwin has shown, is another case, and he observes of *L. perenne* that "its own pollen is as powerless on the stigma as so much inorganic dust."§

3. *Several plants are known to be morphologically self-sterile*, in that the pollen cannot, without aid, reach the stigma, but is effective on that of the same flower. Species of Lupine and *Salvia* are in this condition.

4. *Self-sterile plants from both the above causes can become self-fertile.* Various conditions appear capable of bringing this about. A lowering of temperature seems to check the vigour of the stamens in a normally proterandrous flower, and by not affecting the pistil equally, the essential organs now mature together. Thus *Eschscholtzia*, which is self-sterile in Brazil, became, with Mr. Darwin, self-fertile in England. The mere withering of the corolla will often secure self-fertilisation, as in the case of pansies (see Plate I., fig. 12) by pressing the anthers or pollen on to the stigmas. The closing of the corolla in the evening may do the same, as with Buttercups, *Anagallis*, *Convolvulus*, and other of the Gamopetalæ, in which the stamens, being adherent to the corolla, the latter, when well expanded in sunlight, causes the stamens to spread away from the pistil, and in this condition the flowers are ready to receive the visits of insects: but by closing, the corolla carries the stamens back again, and so self-fertilisation may be secured.

* Space will only allow me to give but little more than an enumeration, but the reader is referred to my paper (*loc. cit.*), where each of these conclusions is dealt with *in extenso*.

† *Loc. cit.* p. 370.

‡ "Animals and Plants under Domestication," ii., p. 135.

§ "Forms of Flowers," p. 98.

A very common condition is for the perianth to remain scarcely at all opened, so that the stamens are never removed from contact with the stigmas. This is the case with small-flowering species of *Veronica* and *Cerastium*, while *Polygonum Convolvulus* and *Hydropiper* never, so far as I have observed them, open their perianths at all.

It would seem probable that plants habitually crossed in their native country, and well adapted for insect agency, may become quite independent of insects in another. Thus the Sweet Pea, though crossed in South Europe, is quite self-fertile here, as is also the garden Pea. The genus *Phaseolus* furnishes a very remarkable illustration, for while *P. vulgaris*, the forcing-bean, is fully self-fertile, yet *P. multiflorus*, the scarlet runner, is dependent on the visits of humble bees for its full fertility; consequently for many years there have been complaints *near London* of the failure of the crops of scarlet runners, all sorts of remedies having been suggested except the right one, which is to abandon it altogether and to grow only the kidney bean instead.*

5. *Highly self-fertile forms may arise under cultivation.* This I take from Mr. Darwin's experiments. In cultivating *Ipomœa purpurea* and *Mimulus luteus* for several generations and comparing the results of crossing and of self-fertilisation, in both cases a self-fertilising form appeared which completely outstripped its crossed competitors. In the latter case "the self-fertilised plants [of the seventh generation] consisted exclusively of this variety;" so it was useless to continue the experiments.†

6. *Special adaptations occur for self-fertilisation.* I have already mentioned a few above, such as the perianth closing or scarcely opening; and will now describe some taken from genera of the natural orders in their usual sequence.

RANUNCULACEÆ.—In small-flowered *Ranunculi*, as *R. hederaceus*, the stamens, instead of spreading away from the stigmas, remain arching over them, and so shed their pollen on to the stigmas. The same occurs with small-flowered *Potentillas*. Some flowers first spread their stamens away, and then incurve them afterwards, as *Agrimonia* (fig. 33) and *Alisma* (fig. 52).

FUMARIACEÆ.—*Fumaria officinalis*.—Mr. Darwin found this to be perfectly self-fertile when insects were excluded. The stigmas resemble two horns, each of which is thrust into a three-sided chamber formed by the three anthers, which have their filaments coherent (figs. 2 and 3).

CRUCIFERÆ.—Large-flowered species are adapted for inter-

* See "Gardener's Chronicle," 1878, p. 561.

† For further details, see "Cross and Self-Fertilisation of Plants."

crossing, though all can probably fertilise themselves by their longer stamens. Small and inconspicuously flowering species are probably in all cases regularly self-fertilised, while some, as Shepherd's-purse, are most abundant and vigorous. The stigmas of these are not two-lobed, but capitate (fig. 1).

VIOLACEÆ.—The genus *Viola* furnishes remarkable cases. The conspicuous flowers of the sweet Violet, adapted to insects, often fail to set seed; but the cleistogamous buds seed profusely. These are degraded buds of the ordinary kind, for in strong growing garden plants transitions can be found, as shown in fig. 4, which represents a bud with the calyx removed. Fig. 5 is a spurred petal, and fig. 6 a stamen with the appendage from another bud; but neither the spur nor the nectary are now of any use. Fig. 7 is the pistil with its curved style, upon which the anthers are pressed. Fig. 8 shows the rudimentary petals of a wild cleistogamous bud of Violet. Fig. 9 is a stamen. Fig. 10 is the pistil, the ovary of which after fertilisation swells and elevates the stamens, which remain clinging to the summit. Fig. 11 is the pistil with the anthers removed, showing the curved style.

Viola tricolor has not cleistogamous buds, but self-fertilising "forms" instead. H. Müller has described one form.* Fig. 13 represents a form of var. *arvensis* which I found having a peculiar development of the placenta. It formed a pillar-like process, which rose up from the "throat" fig. 14 and protruded from the orifice in the globular "head." Pollen-tubes penetrated the centre of the pillar in abundance. Fig. 15 is another form, in which the placentiferous process was lengthened out over the "lip," and resembled a long tongue, which thus licked up the pollen from the calcarate petal.

POLYGALACEÆ.—*Polygala*, though clearly adapted to cross-fertilisation, is yet often self-fertilised. The anther cells grip the spoon-like process on either side, and pour their pollen into it; then the stigma becomes pollinated by bending back upon it according to Hildebrand, from whom fig. 17 is taken. In one form which I found, the anthers were on an exact level with the stigma, so that the pollen tubes were penetrating it from either side (fig. 18).

CARYOPHYLLACEÆ.—This order supplies many "weeds," and weeds are mostly self-fertilising. Fig. 19 represents a bud of *Spergula arvensis*, which remained quite closed (in January), but was seeding freely all the while. Fig. 20 is the same with the calyx and corolla removed. Chickweed behaves in the same way (fig. 21). Both of these, like Shepherd's-purse, will blossom and fruit all the year round as long as the weather wil'

* See "Nature," Nov. 20, 1873.

permit, but often without or scarcely opening their flowers in the winter months.

MALVACEÆ.—Large-flowered species of this order are strongly proterandrous. Thus *Malva sylvestris* will have shed all its pollen before the stigmas are elevated; but *M. rotundifolia*, as Müller has shown, is self-fertile, by the stigmas maturing simultaneously with the anthers, and bending down to intertwine them selves amongst the latter (fig. 22). The curvature of the stigma to secure self-fertilisation is generally due to the more rapid growth of the pistil under confinement of the petals, so that the styles are forced back. This position is then retained on the expansion of the flower.

LINACEÆ.—Though the genus *Linum* has species usually dimorphic and physiologically self-sterile, it must be understood that these conditions are not absolute and unchangeable. There is no reason for supposing they cannot be lost in any case, as indeed they often are in some. Thus the Clove Pink is strongly proterandrous, yet became self-fertilising in three generations with Mr. Darwin. *Linum perenne* was physiologically self-sterile with Mr. Darwin, yet Mr. Meehan has found an instance of its being quite self-fertile in America. *Linum catharticum* on the other hand is not dimorphic at all, and can be crossed or self-fertilised (fig. 23).

GERANIACEÆ.—Our wild species of *Geranium* furnish interesting transitional conditions from the proterandrous state to the self-fertilising, the former being seen in large-flowering forms, as *G. pratense;* the latter in the smaller ones, as *G. pusillum.** The common garden *Pelargoniums* are usually proterandrous, often strongly so, as the "oak-leaved" or "lemon-scented;" but pale-flowered "scarlet-geraniums" (*P. zonale*) are perfectly self-fertilised by the stigmas being scarcely elevated above the anthers, and recurving amongst them (fig. 24).

Oxalis and *Impatiens* have cleistogamous flowers. Figs. 25–28 represent the former, and figs. 29–31 the latter.†

LEGUMINOSÆ.—The papilionaceous corolla is obviously adapted to intercrossing, and in some cases the flowers are morphologically self-sterile; but there are many small-flowered species which are self-fertilising (fig. 32).

ROSACEÆ.—The remarks made about *Ranunculus*, which has many stamens like the Rosaceæ, apply to this latter order. Several small-flowered species, as *Potentilla Fragrariastrum*, retain the incurved position of the stamens; others, like *Agri-*

* For details, see Lubbock's "British Wild Flowers in relation to Insects," p. 43.

† For descriptions, see below, p. 13.

monia, spread them out on first opening, but bend them in again subsequently; while in others, though the outermost stamens may mature before the carpels, yet the inner will mature together with them, so that both intercrossing and self-fertilisation are possible.

ONAGRACEÆ.—*Epilobium angustifolium* and *hirsutum* are proterandrous, but the small-flowered species scarcely open their blossoms at all, and the pollen-tubes may be easily seen penetrating the stigmas from the grains within the anther-cells, which thus become "glued" to the stigmas. Figs. 34 and 35 represent the stamens and pistil of *Circæa lutetiana*. On first expanding, the anthers are close to the stigma, but they afterwards spread away as if adapting themselves for insect fertilisation. The stigma, however, has often become pollinated early, and is thus dragged to the side by sticking to the anther.

COMPOSITÆ.—Contrary to the general opinion, many of this order appear to be constantly self-fertilised. Fig. 36 shows how the stigmatic branches in the *Cichoraceæ* become strongly recurved so as to penetrate amongst the pollen-grains. Independently of that, however, some of the grains mostly fall into the "cleft." In Groundsel the stigmatic arms are often retained below, but separate, within the anther-tube, and so self-fertilisation is secured. Indeed the heads of this order constitute a sure way of securing seed, for the florets can impregnate one another, which is quite equivalent to self-fertilisation.

LABIATÆ.—This order, with its highly differentiated corolla, is obviously adapted to be intercrossed, but it has, like most, if not all others, self-fertilising species. Thus *Lamium amplexicaule* has cleistogamous flowers (fig. 37–39); while *Salvia clandestina* has its stigmas recurved between the anthers (figs. 40–42). *Prunella* (fig. 43) is also often self-fertilising.*

SCROPHULARIACEÆ furnishes several self-fertilisers, though of course, as in the Labiatæ, the great variations in the corollas are so many special adaptations to insects. Some genera, like *Euphrasia* and *Rhinanthus*, are dimorphic: one form with a larger corolla has the stigma thrust forward as in fig. 44, but the other and smaller flower has the stigma strongly recurved so as to reach the anthers (fig. 45). The common garden *Calceolaria* (fig. 46) is quite self-fertile, the stigma being in close conjunction with the anthers; but there are several species, such as *C. glutinosa* and *Pavonia*, forming the section "*Aposecos*" (see "Genera Plantarum," sub nom.), which have the anthers disjoined with a long connective between them, so that they oscillate exactly like the anthers of the genus *Salvia*.

PRIMULACEÆ.—The genus *Primula* has several species di-

* For descriptions, see below, p. 14.

morphic, but others, such as *P. scotica*, are not; and *Primula veris* and others which are usually dimorphic can become homomorphic, as in fig. 47, which is a short-styled form of the Primrose (according to the position of the anthers), but self-fertilising in consequence of the style having elongated. *Glaux maritima* (fig. 48) has the style often recurved so as to secure pollination.

PINGUICULACEÆ.—*P. lusitanica* is self-fertilising by the stigma being recurved and dipping into the two gaping anther-cells, as represented in fig. 51.

POLYGONACEÆ.—Conspicuously flowering species like the Buckwheat, which is dimorphic, and *P. Bistorta*, with pink flowers, are attractive to insects; but Müller has shown that *P. aviculare*, with its minute blossoms, and without honey-glands, is self-fertilising, while *P. Convolvulus* and *P. Hydropiper* appear to me to be habitually cleistogamous.

ALISMACEÆ.—The stamens of *Alisma Plantago* in the first stage of the flower are spread away as represented by the left-hand stamen in fig. 52, but subsequently they bend back; and, although the anthers are extrorse, they lie immediately over or among the stigmas, which are also bent towards them, as in the right hand of fig. 52.

ORCHIDACEÆ.—This order, as is so well known, is almost entirely dependent upon insect aid for fertilisation, yet the Bee Ophrys is self-fertilising, in consequence of the pollinia falling out of the anther-cells, and being retained by their glands, swing backwards and forwards, and so strike against the stigma (figs. 53 and 54). The other case mentioned by Mr. Darwin is *Cephalanthera* (fig. 55), of which he remarks:—"Whilst the flower is still in bud, or before it is as fully open as ever it becomes, the pollen-grains which rest against the upper sharp edge of the stigma (but not those in the upper or lower parts of the mass) emit a multitude of tubes, deeply penetrating the stigmatic tissue." *

COMMELYNACEÆ.—I have figured a case of self-fertilisation in *Tradescantia erecta*, which I found at Kew (fig. 56). It was late in the autumn of 1876, and none of the flower-buds expanded. The corolla in all cases withered within the bud, and several of the stamens were imperfect; the style was bent down beneath the shrivelled corolla, and was pollinated by one perfect stamen. The fruits set seed, which I subsequently grew.

GRAMINEÆ.—*Hordeum murinum*, as far as I am aware, is always cleistogamous. The filaments do not seem ever to escape from the closed glumes, but remain doubled or twisted back, so that the anthers lie in contact with the stigmas (fig. 57).

* "Fertilisation of Orchids," p. 106, 1st ed.

The preceding will be sufficient to prove that self-fertilisation is a great and wide-spread fact in the vegetable world; and that, so far as the plants themselves are concerned, they show no features which imply degeneracy of any kind. They are very abundant. Nearly all of our "most troublesome weeds" are habitually self-fertilising, and show no signs of extinction whatever. Their power of propagation is simply enormous.

Now arises the question as to what is the right interpretation of this fact. My idea is, that self-fertilisation is the legitimate or primeval condition of plants; that for the sole end of plant-life—propagation—extraneous aid is quite superfluous; and that plants have become adapted to insects, is, so to say, an accidental circumstance of no value at all, so far as the securing of a sufficient supply of seed is concerned; that the notion that plants *must* be crossed to be kept up is a wrong surmise, which is not really at all borne out even by Mr. Darwin's experiments.

Let us briefly review those results. One plant alone was cultivated for several years, *Ipomœa purpurea*, or the so-called *Convolvulus major*. On turning to page 53 of his work on "Cross and Self-fertilisation of Plants," the respective heights of the crossed and self-fertilised individuals will be seen exhibited in a tabular form. There is no steady increase in favour of the intercrossed, but a series of *maxima* and *minima*. On the other hand, *there is a steady decline in the heights of the crossed* when a series of averages are taken for every successive three years, a fact which Mr. Darwin does not seem to have observed. Although the actual heights of the intercrossed plants were in every year greater than those of the self-fertilised, yet the ratios taken as above proposed are as follows: For the first three years as 100 : 74·3; for the second three years as 100 : 77·6; and for the third three as 100 : 81·6. The interpretation of this can only be that while "crossing" imparted a stimulus to vegetative vigour, *it is not permanent*, but at the above rate of decrease the crossed plants would have become lowered in height, and be equal to the self-fertilised in a few more generations.*

With *Mimulus luteus* a strong self-fertilising form arose under Mr. Darwin's cultivation, so that it was quite useless to continue the experiment after seven generations, as the self-fertilised form entirely surpassed the intercrossed.

As it was with the heights so was it with fertility. The advantages gained at first were not apparent after a few generations, and the self-fertilised, then, beat their opponents.†

* 100 is the assumed standard for the intercrossed; the ratios, therefore, appear to show a steady improvement in the self-fertilized.

† For arguments and statistics I must again refer the reader to my original paper (*l.c.*).

Mr. Darwin did not cultivate any other plants sufficiently long to enable one to test the results of the permanency of the effects of crossing; but what I wish to point out is that we must not confound permanent morphological characters obtained by crossing with any physiological benefit necessarily and much less permanently resulting from it. Mr. A. Knight's varieties of peas obtained by crossing may have retained their morphological characters by which they were known in the market for sixty or more years; but to imagine that their longevity was due to the fact of crossing, is an assumption based upon no proof whatever. Mr. Darwin's experiments appear to me to prove the exact contrary, for in no case does he show that the physiological effects are more than transitory, even when the offspring are fresh crossed every year; while, on the other hand, Mr. Knight's peas were actually propagated for sixty years by self-fertilisation alone.

The reader will now ask, "What, then, is the good of crossing at all?" I reply, as far as the sole object of plant-life is concerned—that is, an abundance of seed—that the species may survive in the struggle for life, *there is no good at all*, and that self-fertilisation is the best and most certain method. And if it be asked why there are so many adaptations to insects, I reply that I believe it was an inevitable response to the irritation caused by the insects themselves. Moreover, insects often do more harm than good, when they discover that they can secure the honey by illegitimately perforating the corolla tube from without.

I believe that plants would never have had conspicuous perianths at all if insects had not visited them; but by causing a continual flow of nutrition to the external whorls, in consequence of their sucking away the juices, hypertrophy has set in, and the result is that *Man*, but not the plant, has gained the benefit, for he can appreciate the innumerable beautiful forms, colours, and scents, which so many flowers now possess. This result, however, is occasionally *at a sacrifice to the plant itself*, in that it has in some cases, but in the minority, lost the power of self-fertilisation; and, consequently, if a plant be an annual or biennial, and be not visited, it must succumb in the struggle for life, and so perish altogether. Self-fertilising plants are mostly annuals and small; both features being of great advantage in maintaining their continued existence. The rapidity of maturation and shedding of seed is perfectly astounding, generation after generation being produced in a few weeks, while the absolute amount of seeds produced is quite incalculable.

Lastly, the self-fertilised plants are the only ones, as a rule, which are cosmopolitan. I must refer the reader to my paper in the "Linnæan Transactions" for detailed lists of localities

where our weeds, such as Chickweed, Shepherd's-purse, *Lepidium ruderale*, *Malva rotundifolia*, *Solanum nigrum*, etc., etc., have established themselves; and the inference I draw is, that assuming other plants to have travelled with them, those which were entirely dependent upon insects have perished, as they were not visited; while those that were independent, as being capable of self-fertilisation, were the best fitted to survive in the struggle for life.

The conclusion I have arrived at is that self-fertilisation is the aim of plant-life, so far as propagation is concerned; that the existence of sexes enables a plant to diffuse itself by the production of independent offspring (seeds) far more readily and abundantly than by bulbs, and other vegetable offshoots; and that the chance of crossing is thus secured which induces variation in the offspring with greater rapidity than would spontaneously take place under self-fertilisation alone.

The cross may bring with it some new physiological peculiarities, which impart a temporary stimulus to vegetative vigour; but there is nothing to prove that this effect is of permanent value. I believe that by the local irritation induced by insects, all the vast diversity of beauty of form, and marvellous adaptations have been effected; but that this last, though vastly enhancing nature from the human point of view, is of no real value, but is often a detriment to the plant itself. Hence I regard self-fertilisation as being proved to be the best condition in plant-life, to enable a species to maintain its existence in the great struggle for life in the world.

DESCRIPTION OF PLATE I.

FIG. 1. Pistil of *Capsella Bursa-pastoris* to show the capitate form of stigma characteristic of self-fertilising *Cruciferæ*.

„ 2. The stigmas of *Fumaria officinalis*; one of them is covered with pollen-grains.

„ 3. One of the groups of anthers, which form a three-sided chamber in which the horn-like stigmas lie and are thus directly pollinated.

„ 4. Bud of a cleistogamous Violet with the calyx removed, from a strong-growing garden plant.

„ 5. A spurred petal from another bud.

„ 6. A stamen retaining the nectariferous appendage, from the same.

„ 7. Pistil from the same, with curved style.

„ 8. Rudimentary petals of a cleistogamous bud of a wild form of Violet.

„ 9. Stamen from same.

„ 10. Pistil with the anthers coherent above, having been detached and elevated by the swelling of the ovary.

„ 11. Pistil with anthers removed.

FIG. 12. *Viola tricolor.* The corolla has withered, so that the spurred petal has pressed the pollen into the orifice, and has remained clinging to it. Both the petal and stamens have become elevated by the growth of the ovary.

„ 13. This represents the style and globular stigmatic "head" of a self-fertilising form of *V. tricolor* var. *arvensis*, in which the placentiferous tissue had grown up like a pillar and protruded from the orifice in the form of a knob. Pollen tubes were penetrating the centre of the pillar in abundance.

„ 14. Vertical section of the preceding.

„ 15. Another self-fertilising adaptation, in which the placenta had grown over the "lip," and was prolonged into a kind of tongue which thus "licked" up the pollen from the spurred petal.

„ 16. Apex of pistil and stamens of *Polygala vulgaris.* The anthers are emptying themselves of pollen into the spoon-shaped extremity of the style.

„ 17 (after Hildebrand). The stigma is seen to become pollinated by bending back into the pollen.

„ 18. A form in which the anthers are on a level with the stigma, into which abundance of pollen-tubes had penetrated.

„ 19. A self-fertilising bud of *Spergula arvensis* (Jan. 1874).

„ 20. Same with calyx and corolla removed.

„ 21. A flower of Chickweed. This, as also the *Spergula*, has the number of stamens reduced to three.

„ 22. The stigmas of *Malva rotundifolia* represented as recurved amongst the anthers, and becoming self-fertilised.

„ 23. Stamens and pistil of *Linum catharticum.*

„ 24. Stamens and stigmas of *Pelargonium zonale.* The stigmas are recurved amongst the anthers and becoming pollinated by them.

„ 25. Cleistogamous flower-bud of *Oxalis Acetosella.*

„ 26. Calyptriform corolla of the same.

„ 27. Anthers of same united together by filamentous processes. (It is not quite clear what these are, but probably *not* pollen-tubes.)

„ 28. Pistil of same, with anthers of two of the latter stamens in contact with the short stigmas. The lower anthers are partly aborted, two filaments only represented.

„ 29. Cleistogamous flower-bud of *Impatiens fulva.*

„ 30. Same with calyx and corolla partly detached from the pistil (after Bennett).

„ 31. Stamens of same.

„ 32. Stamens and pistil of small-flowered leguminous plant, such as *Medicago denticulata*, the ten anthers being clustered round the stigma, both maturing together.

„ 33. A stamen and a flower of *Agrimonia*, the corolla removed, with stamens incurved, some time after expansion.

„ 34. First stage of *Circæa lutetiana* on expansion. The anthers are close to the stigma.

„ 35. The second stage of the same, the anthers now spread away. The stigma having been pollinated, is drawn to one side by mechanical adhesion to the anther.

FIG. 36. Anther-tube and recurved stigmas, characteristic of the tribe *Cichoraceæ* of *Compositæ*.

„ 37. Cleistogamous flower-bud of *Lamium amplexicaule*.

„ 38. Vertical section of the same, showing the stigmas lying between the anthers.

„ 39. The pistil removed to show how the style has become bent under constriction of the corolla.

„ 40. Corolla of *Salvia clandestina*. The essential organs are quite invisible.

„ 41. Stamens of the same. The anthers stand edgeways, so that the lines of dehiscence face each other.

„ 42. The styles removed. In one, the very long stigmas are unrolled artificially.

„ 43. Stamens and stigmas of *Prunella vulgaris*. The posterior branch is being pollinated.

„ 44. Two stamens and pistil of *Rhinanthus Crista-galli* var. *major*, adapted for intercrossing by the stigma being protruded.

„ 45. Two stamens and pistil of same, var. *minor*, adapted for self-fertilisation by the stigma being reflexed.

„ 46. Stamens and pistil of the garden variety of *Calceolaria*.

„ 47. Homomorphic form of Primrose, which produced plenty of good seed.

„ 48. Flower of *Glaux maritima*, with the stigma recurved to secure self-fertilisation.

„ 49. Side view, and

„ 50. Front view of the pistil of *Pinguicula lusitanica*.

„ 51. Pistil and the two stamens of same. The stigma is inserted into the anther-cells.

„ 52. Two stamens and one carpel of *Alisma Plantago*. One stamen is spreading as for intercrossing; the other is reflexed, a subsequent condition, for self-fertilisation.

„ 53. *Ophrys apifera*, showing the pollinia falling from the anther-cells in the position for striking against the stigmatic surface.

„ 54. Pollinium removed, showing the bend in the caulicle.

„ 55. Stigma and pollinium of *Cephalanthera*.

„ 56. Self-fertilising flower-bud of *Tradescantia erecta*. The withered corolla is partially removed, the calyx not being represented. The stigma is being pollinated by the one perfect anther. The rest are aborted.

57. Stamens and pistil of *Hordeum murinum* as they occur in the permanently closed florets.

THE OLDEST MOUNTAIN IN ENGLAND.

By C. CALLAWAY, M.A., D.Sc. Lond., F.G.S.

IN determining the antiquity of a mountain, we have to ascertain either the period at which the mineral matter of which it is composed was brought together, or the epoch in which the mass was lifted above the surface of the ocean. The Swiss Alps, for example, are largely composed of strata deposited in several epochs from the Carboniferous upwards, but these mineral masses were not upheaved until the comparatively recent period of the Eocene Tertiary. Or to take an illustration nearer at hand. The Cotswold Hills are mainly composed of oolitic limestone, which was once a muddy sea-bottom of the Jurassic epoch, but as a mountain range they did not exist before Tertiary times. If we regard the period of their origin as a mineral mass, we shall call them Jurassic; but if we consider only the period of their elevation, we shall describe them as Tertiary.

If we regard only the epoch of the *mineral* origin of a mountain, the Malvern Hills have probably the best claim to priority. They consist of schistose rocks, which were deposited as sand and clay in an ocean which probably dates as far back from the Cambrian epoch as the Cambrian epoch dates from ours. Whether or not we accept Dr. Holl's determination of their Laurentian age, it is certain that the Cambrian strata, the oldest rocks in Britain which contain the remains of organic life, succeeded them at an immense interval of time. It is possible that some portion of the Malvern ridge stood above the waves in Pre-Cambrian times, but proof of such elevation is wanting. It is clear, however, that the Malvern Hills existed in part before the close of the Cambrian epoch. For details on these points reference may be made to Phillips's "Geology of Oxford and the Valley of the Thames," and to a paper by Dr. Holl in the "Quart. Journ. Geol. Soc.," Feb., 1865.

The hill for which is claimed the title of "Father of English mountains" is the Wrekin, which stood above the ocean in Pre-Cambrian times, and had attained the dignity of a mountain

early in the Silurian epoch. This hill is only one of a chain twenty miles long, but it is selected as the one most carefully studied by the writer.

The Wrekin is about two miles south-west of the town of Wellington. It rises sharply up from the Triassic plain of North Shropshire, and stands out as the advanced guard of the numerous ridges which intersect the southern half of the county. But it is six or seven miles distant from the main groups, and its isolation gives it great prominence. It is only 1,320 feet in height, but it is said to be the highest mountain in Europe for the circumference of its base. The range of which it is the most conspicuous elevation is three miles in length, trending north-east and south-west, and is cut into three separate masses by two deep and narrow gorges. The Wrekin proper is one mile and three quarters long, and about half a mile in breadth at the base. Its shape is peculiarly graceful. Viewed from almost every point its outline forms an unbroken curve. From the north-west it appears like a quarter moon resting on the earth with its convexity upwards. From the south-west it presents the outline of a perfectly symmetrical arch. The legend runs that this arch was piled up by an industrious giant. Science tells us that it was originally thrust up between two parallel dislocations or faults as a gigantic wedge, and was subsequently rounded into its present elegant form by the busy fingers of frost, carbonic acid, and rain, working unceasingly through immeasurable ages.

No authentic account of the origin of the Wrekin has yet been published. A pseudo-scientific description from a local guide-book of the birth of the mountain is little less mythical than the legend of the giant's arch. The reader is gravely informed that "when the struggling gases below the Silurian ocean made an effort to be free, a power of indescribable force shook the earth, upheaving the ocean bed and throwing up precipitous hills above the waves; and so, amidst boiling waters, hissing steam, and exploding gases, the Wrekin and its adjacent hills rose to their present elevation."

The account of the structure of the Wrekin in Murchison's "Silurian System" is more rational, but it is equally erroneous. The mountain is described as a mass of disruptive greenstone forced up into the midst of Caradoc sandstone and shale, and altering the sandstone into the hard white crystalline rock called quartzite. This account of the Wrekin is endorsed by the Geological Survey, whose map and sections of the district were published during the time Murchison was Director General. According to this hypothesis, the mountain is necessarily younger than the Lower Silurian strata on its flanks. But no terms could more unfitly describe it than "disruptive green-

stone." Greenstone is a dark crystalline volcanic rock, poor in silica, and characterised by the large proportion of iron, magnesia, and lime contained in it. But the Wrekin is chiefly composed of rocks of a pink, red, or grey colour, rich in silica, and deficient or wanting in iron, lime, and magnesia. This rock, so far from being disruptive, was deposited in beds not only before the Caradoc epoch, but long anterior to the much older Cambrian strata. Let us examine these points in more detail.

In modern volcanic eruptions the ejected matter is either felspathic or augitic. The latter is dark coloured, and contains a large proportion of the bases named as characterising greenstone; indeed, we may consider augitic lavas as the modern representatives of the ancient greenstones. The felspathic ejections of volcanoes are either molten as lava-flows, or fragmental as ashes and breccias. They are generally lighter in colour, and, containing less iron, are not so heavy. No essential distinction can be made between ancient and modern igneous rocks. Both are the result of the same heat forces. In all ages volcanic action has been ejecting ashes, pouring forth floods of molten lava, and injecting into fissures of the crust melted matter which cannot reach the surface as lava. Beds of ashes, layers of lava, amorphous masses of molten rock, the common products of Etna and Vesuvius, were formed in all geological epochs. The separation of igneous rocks into volcanic or modern, and plutonic or ancient, is arbitrary and unphilosophical, and is furthermore calculated to mislead the student by suggesting that plutonic rocks were formed under mysterious and unknown conditions. Mr. Allport has shown, by both chemical and microscopic analysis, that the rocks of the Wrekin are identical with the modern ejectamenta of volcanoes. Certain changes have taken place during the lapse of ages by the action of infiltrated atmospheric waters, but it cannot be doubted that originally the volcanic rocks of the Wrekin were essentially the same in composition and in mode of formation as the materials of modern volcanoes. This is one of the most important generalisations of recent years, and it derives additional interest from the discovery by the writer of the Pre-Cambrian age of the Wrekin. Mr. Allport carried back the period of existing volcanic action to what he considered Silurian times. In this paper it will be shown that in times perhaps more remote from the Silurian than the Silurian is from ours, the volcanoes of Shropshire ejected lava and ashes undistinguishable from the products of existing craters. The fire forces may have been more energetic, but they produced the same results in the same way. The volcanoes which in Pre-Cambrian times covered with their lavas and ashes the area now called South Shropshire were

doubtless more quickly thrown up, and it is not unlikely grew to vaster proportions, than the average of existing volcanic mountains, but there is no essential difference in their physical and mineral constitution.

It must not be supposed that the Wrekin represents a volcano such as Etna or Vesuvius, or even such dilapidated cones as are dotted over the Miocene region of Central France. In the Wrekin there is no trace of cone-structure whatever. The mountain is bedded like the limestones and shales of Wenlock Edge, or the Chalk strata of Sussex. Even in volcanoes of Tertiary age, denudation has often left nothing remaining but the amorphous roots or foundations of what was once a lofty and symmetrical cone; and in regard to volcanic mountains of an epoch to which the Tertiary periods are but as yesterday, we have infinitely less reason to expect any traces of the original cone-structure.

The Wrekin is chiefly composed of a great bedded series consisting of alternations of felstones (felspathic lavas) and felspathic tuffs. At the north-east end are beds of volcanic breccia, alternating with fine-grained ashes. Underlying these are pink and white felstones, displaying a distinct banded structure, due, it is supposed, to the flowing motion of the rock in its original form as molten lava. Towards the summit of the mountain we come again to a hard pink breccia; and at the summit the rock is a compact purple felstone. On the south-west flank of the hill is another exposure of tuff. The spur called Primrose Hill, the south-west extremity of the range, is composed of a brick-red felstone, passing, by the addition of quartz and a little mica, into an imperfect granite.

These lavas and tuffs have a distinct dip to the north, or a little to the west of north, at an average angle of about 45°. The direction of the ridge being N.E. and S.W., and the strike of the beds being about east and west, it will be seen that the beds strike across the ridge at an acute angle, so that the direction of the range and the shape of the mountain are not materially determined, as is commonly the case in mountains composed of ordinary stratified rocks, by the strike and dip of the beds. A section drawn at right angles across the ridge represents the strata with a seeming dip to the north-west at a low angle. This will be readily understood when it is remembered that such a section would cut the direction of true dip at an acute angle. This discordance of the strike of the strata with the strike of the range will remind geologists of the structure of the Malvern Hills, in which schistose rocks strike north-west and south-east across a north and south ridge.

It has been shown that the volcanic rocks of the Wrekin are as clearly stratified as the limestones and shales of Wenlock

Edge; but it must not be supposed that the beds are so regular and persistent. The limestone of Wenlock Edge is continuous and unbroken for nearly twenty miles; and in the United States, the Corniferous Limestone extends from the Hudson to the Mississippi. But the lavas and ashes of the Wrekin form lenticular masses rather than regular beds. It is rarely possible to follow a stratum along its line of outcrop for many hundreds of yards. The breccias especially thin out very rapidly. But this is precisely what the analogies of modern volcanic action would lead us to expect. The layers of lava and tuff of which a cone is composed, and by which it is surrounded, thin out rapidly towards the circumference of the volcano, and the coarser the material the less persistent is the bedding. Volcanic matter ejected under the sea, as was the case with some, if not all, of the Wrekin beds, is deposited more evenly and over a much wider area; but the principle is the same.

Associated with the stratified rocks of which the mountain is chiefly composed, are certain masses of much less antiquity, to which the term "greenstone" may appropriately be applied. In ascending the Wrekin from the north-east end, we notice in the centre of the ridge, about midway between the north-east end and the summit, a bare rounded hump, which on examination proves to be a mass of greenish dolerite or basalt, which has been forced up when in a molten state through the midst of the older bedded series, disturbing their strike, and apparently, in one place, reversing their dip. From this disruptive boss proceed several vertical dykes of basalt, three of which can be well seen at the north-east end of the mountain, striking towards the central mass. This basaltic rock was probably erupted in newer Palæozoic times, but its exact age does not affect our present inquiry. The Wrekin existed as a distinct elevation many epochs before the dolerite boss and dykes were formed, and their bulk is unimportant compared with the mass of the mountain.

The Wrekin, though mainly, is not exclusively composed of igneous rocks. Buttressing the ridge on both sides are certain beds of quartz rock, about two hundred feet thick, dipping away from the axis at an average angle of 45°. They also lap round the ends, and their dip is, in every case, away from the mountain. This quartzite evidently once formed a continuous bed of sandstone, and, judging from the dip of the pre-existing volcanic strata, was deposited unconformably upon them. Then an upheaving force produced two cracks in the rigid crust of bedded felspathic rock, and pushed up between the cracks a narrow wedge, which, in its turn, forced a way up through the sandstone, tilting it off on all sides, and crushing up its lower surface into a breccia.

Previous to this elevation, or perhaps subsequently, the sandstone was converted into quartzite.

On its north-west side, the Wrekin, with its overlying quartz rocks, is bounded by a fault separating it from the Bunter sandstone, the lowermost division of the Triassic rocks of North Shropshire. But on the south-east the quartzite is succeeded by green sandstones, formerly supposed to be of Caradoc age, which the writer has demonstrated to be the true Hollybush Sandstone of the Malvern Hills.* Not only does this rock contain two common Malvern fossils, *Kutorgina cingulata and Serpulites fistula*; but it is precisely similar to the Malvern sandstone in lithological and mineral characters. Outside of this band of Hollybush Sandstone is a parallel zone of shales, which have been shown in the same paper † to be of Tremadoc age. The quartzite, the Hollybush Sandstone, and the Tremadoc Shales are separated from each other by faults, and, from the structure of the whole country, it is clear that they were successively deposited at distant intervals. The Tremadoc Shales are Upper Cambrian; the Hollybush Sandstones are probably Lower Cambrian; and the quartzite has been shown by the writer ‡ to be Pre-Cambrian.

It was intimated early in this paper that some part of the Wrekin rose above the waves in one of the Pre-Cambrian epochs. In the lower part of the quartzite, on the south-east side of the mountain, small pebbles of decomposed felstone, showing the characteristic banding of some of the Wrekin rocks, are imbedded. Besides this, the quartzite is wanting under the summit of the hill on both sides, so that the summit was probably dry land during the deposition of the sandstone. These facts seem to point to the following sequence of events. The Pre-Cambrian sandstone (now quartzite) was deposited round an island of felspathic rocks, the partial denudation of which supplied the pebbles. Subsequently, the wedge-like upthrust previously described took place, and a north-east and south-west ridge of felspathic rock, set in a framework of sandstone or quartzite, rose above the waves of the Lower-Palæozoic Sea.

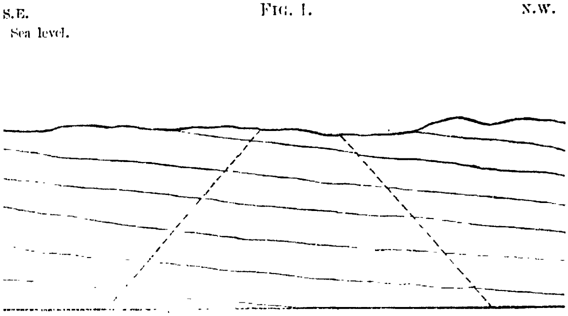
That rocks of the Wrekin chain formed dry land in times preceding the Cambrian will be further evident from the following considerations. In a low elevation, about two miles west of the Wrekin, is a good exposure of Pre-Cambrian rocks with their usual east and west strike. These ancient strata here contain a band of well-marked conglomerate, consisting of rounded pebbles of quartz, mica-schist, pink felstone, and an imperfect granite.

* "Quart. Journ. Geol. Soc." vol. xxxiii. p. 662.
† Ibid. pp. 657–662.
‡ Ibid. vol. xxxiv. p. 754.

The felspar rock and the granite closely resemble some of the Wrekin felstones and bastard granites; but, however this may be, it is certain that the conglomerate, being a shore deposit, was derived from neighbouring land. It is clear, then, that some portion of the Wrekin mass—not necessarily, though very probably, the actual Wrekin wedge—was elevated above the Pre-Cambrian ocean.

Figs. 1 & 2 are an attempt to represent two stages in the Pre-Cambrian history of the Wrekin.

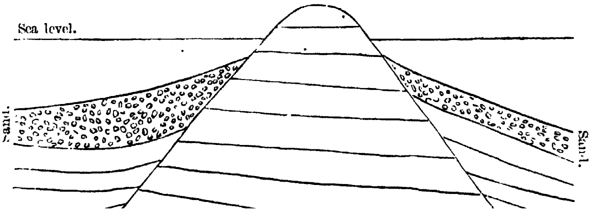
FIG. 1.



THE WREKIN—FIRST STAGE.

Beds of tuff and lava have been formed by volcanic eruption. They have been tilted up with a considerable dip to the north, which is represented as a slight dip to the north-west, the section being taken at right angles across the present axis of the hill. They have since suffered considerable denudation, and now form the bottom of the Pre-Cambrian sea. The Wrekin commences an independent existence by its separation from the main mass by two parallel faults, represented by the dotted lines.

FIG. 2.



THE WREKIN—SECOND STAGE.

The wedge is now thrust up above the level of the waves, disturbing the adjoining beds in its upward motion. A portion of the ridge forms an island, which furnishes pebbles to the sands (afterwards quartzite) which are accumulating round its margin.

Whether or not the Wrekin stood above the sea in the Cambrian epoch is difficult to determine. In the Lower Cambrian

strata of Haughmond Hill, near Shrewsbury, the "busky hill" of Shakspere's *Henry IV.* is a great bed of conglomerate, coloured "greenstone" on the map of the Geological Survey. The pebbles of which this rock is mainly composed are of reddish felstone, resembling some of the Wrekin felstones. This conglomerate was certainly derived from land of a similar mineral structure to the Wrekin, and it is only six miles distant from that elevation; but it would be somewhat rash to assume that the Wrekin was the only mass from which the felstone pebbles could have been derived. There is, however, no doubt that Pre-Cambrian land existed in Lower Cambrian times somewhere in the neighbourhood of the Wrekin.

Emerging from the dimness of these ancient epochs, we come into the clearer light of the Silurian period. The dawn of that age shone upon the Wrekin rising sharp and lofty above the waves. During the Arenig and Llandeilo periods, the forces of the atmosphere were incessantly employed in reducing its size and rounding its outlines. In a south-westerly direction, its base, consisting of a framework of Upper Cambrian shales, extended several miles. Towards the Caradoc epoch, the Wrekin island began to sink, and was lapped round by Lower Caradoc sandstones and conglomerates. The depression still went on, successive strata of the Caradoc formation overlapping each other on to the sloping Cambrian margin. In the Lower Llandovery period the motion was reversed, and no strata were deposited round the island; but in Upper Llandovery times depression was resumed, and was continued till the Pentamerus Limestone and its associated conglomerate margined the very flanks of the Wrekin itself, and the succeeding deposits of the Wenlock and Ludlow periods probably surrounded and buried the greater part or the whole of the mountain.

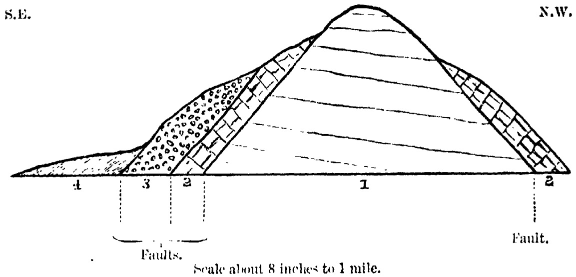
During the period of the Old Red Sandstone, the Wrekin rose again above the ocean, while the forces of the sea and air were actively at work in stripping off the superincumbent layers of Upper Silurian rock, and once more exposing the buried mountain to the light of day.

Early in the Carboniferous epoch, depression once more commenced, and sandstones were deposited round the lower slopes of the Wrekin, succeeded by coral-reefs and banks of shells. Then the surrounding sea gradually shallowed, gave place to low swampy land covered with ferns, lycopods, and sigillariæ, and inhabited by insects. These land surfaces, by oscillations of the crust, alternated with clays containing marine shells and king-crabs.

The later part of this period was marked by active vulcanism. Numerous volcanic cones were dotted over the West-Midland counties. The Rowley Hills, near Dudley, and the Clee Hills, in

South Shropshire, are good instances of the remnants of these eruptions. Immediately to the south-east of the Wrekin, and forming a parallel ridge, is a great layer of dolerite, which had been intruded amongst the Lower Carboniferous rocks, and exposed by subsequent denudation. This mass has by some writers been lumped together with the ancient felspathic rocks of the Wrekin; but there is no reasonable doubt that it belongs

FIG. 3.



Scale about 8 inches to 1 mile.

THE WREKIN—ADVANCED STAGE.

Fig. 3 represents the Wrekin in its present form. The wedge has been further uplifted, tilting up on its flanks the beds of Pre-Cambrian sandstone (now quartzite). On the south-east side are also seen two sub-formations of Cambrian rock. In early Silurian times, the general relations of the several groups must have been as here represented; though the volcanic nucleus was doubtless buried under masses of Cambrian strata. The superincumbent envelope must have been removed, and the volcanic wedge exposed to the light of day, before the Silurian period had reached its meridian.

1. Bedded Pre-Cambrian volcanic tuff, dipping north.
2. Quartzite.
3. Hollybush Sandstone.
4. Shineton Shales (Tremadoc).

to the same eruptive period as the Rowley and Clee Hills. The disruptive boss and dykes previously described as occurring at the north-east end of the Wrekin, are probably of the same epoch. The boss may, indeed, be the consolidated remains of the molten rock which filled a pipe or neck, and which subsequently intruded itself between the adjacent Carboniferous strata, though the two masses are now isolated by the denudation of the intervening valley.

In the period of the New Red Sandstone (Permian and Trias) the depression was continued, and the Wrekin was more or less buried under deposits of red sandstone, accumulated, in all probability, in inland seas or lakes. These sandstones may subsequently have been covered in by the marine strata of the Jurassic and Cretaceous epochs.

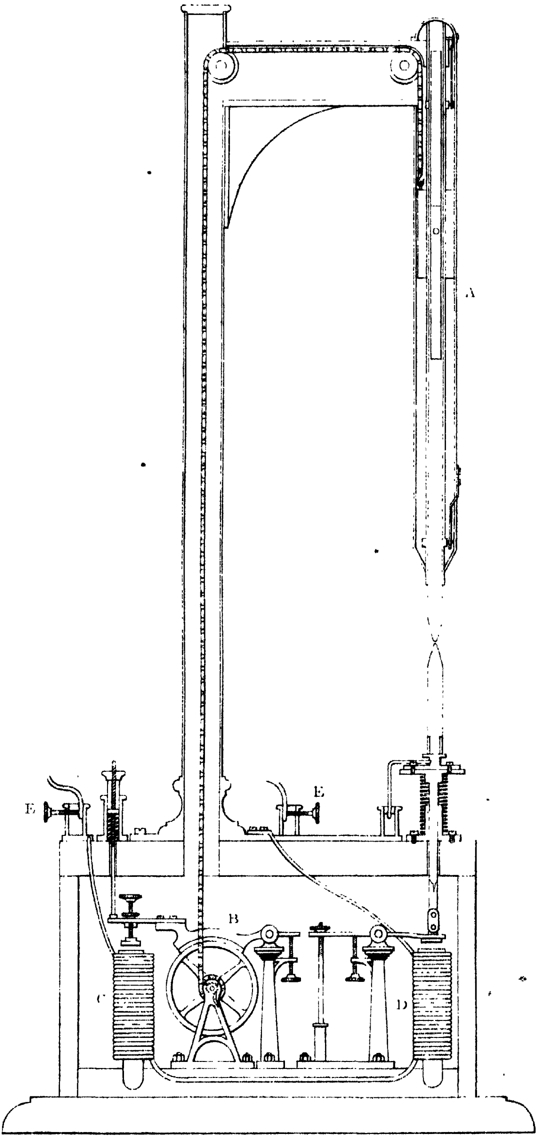
In some period succeeding the Trias, certainly later than the Lias, probably at the close of the Mesozoic, great dislocations took place in a north-east and south-west direction. In very early times lines of fracture had been established at the base of the Wrekin on each side. Between two of these faults the Wrekin had originally been thrust up as a solid wedge of the earth's crust. The disturbing forces had, during successive epochs, in the manner described, been acting along these lines of weakness. The wedge had been alternately uplifted and depressed, and, in some cases, large areas surrounding the lines of more violent movement had, to a greater or less degree, shared in the motion. These movements were renewed, with great violence, at the close of the Mesozoic epoch. Triassic sandstones, as the result of these dislocations, now lie faulted against the base of the Wrekin, just as they lie along the eastern flank of the Malvern Hills; and, farther to the south-west, Triassic, Permian, and Carboniferous strata are in succession thrown down against Cambrian and Silurian rocks.

During successive Tertiary ages, the Wrekin was gradually disincumbered of its enclosing Mesozoic envelope by the united action of marine and sub-aerial denudation.

In the Glacial epoch, the mountain again suffered submergence, partial or entire. Marine sands, containing boreal shells, are found on its lower slopes, and testify to the presence of the ocean. Subsequently to the formation of these deposits, icebergs from the north, laden with boulders of granite and felsite, were stranded against the flanks of the mountain, and deposited their rocky burdens. It is also probable that the Wrekin was wholly or in part buried beneath continental ice during some part of this period.

Last of all the sea retired, and the Wrekin made its final emergence from the waves. No material change has since then taken place; but the atmospheric forces have been and are still at work. Frost, with its million wedges in every square foot of exposed surface, reduces the hardest felstone to powder. Carbonic acid, dissolved in rain-water, penetrates the felspathic rock, dissolves out the alkaline ingredients, and produces gradual decay. Finally, the falling rain washes down the particles loosened by frost or softened by decomposition, and the streams that drain the mountain deposit them on the lower ground, or carry them into the Severn. Thus this "Æonian hill," composed as it is of hard and intractable mineral matter, is being imperceptibly but inevitably reduced to powder, is "drawn down" by streams, and "sown" as

"The dust of continents to be."


A
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E
B
C
D

THE ELECTRIC LIGHT.

By W. H. STONE, M.D.

[Plate II.]

There has been no lack of material for the increased public interest which has of late been exhibited in the practical development of science; and the last instance differs materially from its forerunners in the great technical and everyday importance which it possesses. Even Telephones and Phonographs are far exceeded in popular attention by inventions which propose to revolutionize the system of general illumination, and to supersede coal-gas—a means of lighting which, though introduced within the memory of many still living, has become so familiar as to be unnoticed. There can be little doubt, moreover, that this popular excitement, though it may not have been intentionally stimulated by sensational announcements, has derived a peculiar zest and pungency from the financial results it has brought about. The great depreciation in shares of gas companies which followed Mr. Edison's announced, but still unexplained, discovery, not only set in motion the world of speculators and financiers, but led the consumer at large to hope for partial or complete emancipation from one of his old tyrants, and for the substitution of an immensely superior method of lighting.

And yet the Electric Light is, strictly speaking, no new subject. Produced by Sir Humphry Davy, at the beginning of the century, from his large battery of 3,000 cells, it has been ever since an essential of the laboratory, and has for many years been occasionally exhibited in public.

A great impetus was, however, given to its study by Faraday's discovery, in 1831, of the induction of currents by magnets, thus dispensing with the expensive and troublesome battery.

Machines of this nature were constructed in 1849 by Holmes, and by the Alliance Company of Paris, which have worked satisfactorily at the South Foreland, Cape Grisnez, and several other lighthouses, for many years.

The current is here produced from armatures rotating in front of fixed permanent magnets, arranged symmetrically round

them. The instrument is large, cumbrous, and expensive. The permanent magnets are liable in course of time to weaken, and, indeed, the apparatus has hitherto only been utilized for the single beam of the lighthouse.

The system has, however, been revived in a modified form quite recently by Mons. de Meritens.

A great advance was made on this stage by Dr. Siemens, Sir C. Wheatstone, and Mr. Varley, in 1867. It was shown, that if an induction coil be made to revolve in front of a soft iron electro-magnet, instead of before a permanent magnet, as in the earlier machines, the small amount of residual magnetism always latent in the iron, especially if it has once been magnetized, causes feeble currents to be induced in the coil; if these currents, or a portion of them, be sent round the iron magnet, into the wire surrounding it, the magnetization is increased. This again produces a proportionate increase in the induced currents in the coil; thus by a series of successive mutual actions, intense magnetization and very powerful currents are produced. Machines constructed upon this principle of reaction have been termed "dynamo-electric" machines, as indicating that dynamical force is converted into electricity. For the older form, where permanent magnets are employed, the term "magneto-electric" has been retained; their power being limited by the strength of magnetization of the permanent magnets made use of. This discovery, by adding considerably to the power of electric machines, led to a corresponding diminution in their bulk, and also in their cost. Almost, if not quite all subsequent machines are "dynamo-electric" in construction, and based on the principle of mutual reaction.*

Those of this kind best known in this country are the Siemens and Gramme machines.

In the former the armature or induction bobbin, on Dr. Siemens' principle, has its enveloping wire wound lengthwise, and parallel to the axis of rotation; it rotates between semi-circular prolongations of large flat electro-magnets placed on either side of it; their north pole being immediately above, the south pole immediately below the axis of the bobbin. It is commonly made of three sizes, the smallest costing £70, consuming 2-horse power to drive it, and giving, with 850 revolutions per minute, an illuminating power of 1,200 candles. The illuminating power of the two larger machines is of 6,000 and 14,000 candles respectively.

The Gramme machine is composed of an induction coil having a ring or cylinder of iron revolving between a pair of electro-magnets. The ring is wound with a number of transverse circles

* From a paper "On the Present State of Electric Lighting," read before the Brit. Assoc. in Dublin by J. M. Shoolbred, B.A., &c.

of wire, each of which when under the inductive influence is tapped by two brushes at a tangent to a circular commutator placed on the shaft, and carrying off the electricity in one continuous direction. It is also made in three sizes, costing respectively £70, £100, and £300, giving the light of 2,000, 6,000, and 15,000 candles.

Hitherto the subject has been considered in regard to single lights; but an important advance consists in securing the divisibility of the current so as to produce a number of lights instead of one. This object has been sought for for the last twenty years, but only practically solved by the Lontin and the Jablochkoff-Gramme systems. Both these work with currents not continuous, but in alternate directions. Indeed, the "candle" of M. Jablochkoff requires this as an essential condition to produce the equal combustion of the two parallel carbons. The Gramme machines have been therefore so modified as to meet this necessity.

Mons. Lontin works on another line. He has designed two machines instead of one. The former is termed the generator, the latter the divider.

The generator consists of a horse-shoe electro-magnet, between the poles of which rotates a coil formed in a star-like shape, of which the projecting arms are wound with wire. A series of these stars is arranged obliquely along the rotating shaft, so as to obviate any abrupt break in the inductive action. Two rubbing contacts collect the positive and negative currents, carrying them through the fixed magnet and so to the second machine.

This, the "divider," has a shaft carrying a series of larger stars with more radial electro-magnets, into which the currents from the generator are passed, so that they remain in a state of magnetic saturation.

Each star revolves in a wrought-iron cylinder, studded on its inner surface with short induction coils corresponding to the radii of the revolving star-wheel. These are coupled together so that their positive and negative poles are presented alternately to those in rotation. The result is a number of currents alternate in direction and equal in number to half the rotating spokes. The alternating current from each ring is collected separately on the exterior, and conveyed to a frame where the various elementary currents may be coupled in any desired number of circuits. The usual apparatus has twenty-four discs, which, by being coupled in pairs, produce twelve circuits, and can supply twelve separate lights, or can be all devoted to a single lamp.

The number of lights produced by one of these engines, which has a total illuminating power of 12,000 standard candles, at the Western Railway in Paris, varies from six to twelve. But as many as thirty have been supplied from a similar machine at the Lyons Railway Station.

For the convenience of M. Jablochkoff, Gramme has lately devised a similar instrument to that described above, except that the revolving drum has eight flat bars of iron wound lengthwise with wire placed radially, and supplied with a continuous current from Gramme's original generator. External and concentric to these are thirty-two coils, forming one or more alternating circuits at will. They are, in practice, coupled together so as to produce four. The intensity of the machine is that of 16,000 candles. As applied to lighting the Avenue de l'Opéra at Paris, by means of sixteen Jablochkoff candles, it is driven at the rate of 600 revolutions per minute, and is said to require an engine of 16-horse power.

Improved methods for the production of the current are far more recent than those adapted for its exhibition. Indeed, a mechanical lamp, hardly, if at all, inferior to those lately patented, dates back as far as April 1855. The specification of Mr. Henry Chapman, sealed on June 12th in that year, is before us, under the title of "An Improved Electro-mechanical Apparatus for Supplying and Adjusting the Electrodes used in the Production of the Electric Light." It works entirely by means of gravity, and dispenses with the costly and easily deranged clockwork of the Serrin, Foucault, and Siemens* lamps, which are all fitter for the physical laboratory than for general purposes. The comparative forgetfulness into which this excellent contrivance (see Plate II.) has fallen is probably due to the failure of the Electric Light and Colour Company which adopted it, and which proposed to compensate for the expense of the battery by producing salts of tin, and other metals useful in dyeing. In its day it was highly successful, and was proposed for use in reconnoitring the enemy's positions during the Crimean war.

Mr. Browning has long advertised several lamps acting on this simple but effective method, although he is entirely antici-

* In the Siemens automatic electric lamp the carbons are held vertically one over the other in the same relative position as in the Serrin lamp. Inside the lamp is a train of wheels gearing into racks formed, one on the stem of the lower and the other on the stem of the upper carbon holder. These wheels are so arranged that, assisted by gravity in the upper carbon holder, which is made sufficiently heavy, the points of the two carbons are caused to remain a precise and defined distance apart, which distance is constant during burning, and by means of which the shortening of the carbons by combustion is regularly followed up. A vane regulator or fly is used to control the rate of descent of the upper carbon and the corresponding ascent of the lower one. Should the carbons approach too closely they are separated by means of an electro-magnet which acts upon the end of an oscillating lever, which, during its periods of oscillation, causes the train of wheelwork to revolve in an opposite direction, and so to separate the carbons and to restore the voltaic arc.

pated by Mr. Chapman's patent, dated more than twenty-three years ago.

Among the more modern systems worthy of notice are the Rapieff, the Werdermann, and the Wallace-Farmer.

The last of these has been brought into prominent notice by its connection with Mr. Edison's still undisclosed discovery.* The Wallace-Farmer dynamo-electric machine divides American patronage with the Brush machine, just as the Siemens machine divides the English market with the Gramme. It comprises a dynamic machine as well as a special form of lamp. The lamp consists of a metal frame of brass, carrying two carbons in the form of slabs about nine inches long and three inches broad; the upper, or positive, being about half an inch thick; the lower, or negative, only about a quarter of an inch. The lower carbon is fixed to the bottom of the frame; the upper is carried by a cross-piece sliding up and down in side grooves. It can, therefore, be drawn apart from the lower to any adjusted distance, so as to determine the luminous arc. When the lamp is not in use, the upper carbon is let down into contact with the lower; but the act of putting on the current raises it one-eighth of an inch, and establishes the light by means of an ingenious mechanism. The arc either starts at the point of least resistance, or may be started by inserting a metal conductor for a moment between the two carbon edges. Once started, it subsists at that point until the consumption of carbon widens it to such a degree that a shorter and less resisting path for the current is to be found at a neighbouring point. In this way the arc travels slowly along the whole edge of the carbon, and when it reaches the other end, it turns and comes back again. The light can thus be maintained for one hundred hours without change of carbon, at a cost of about a penny per hour.

There can be no doubt that where exact stability in position of the luminous arc is not essential, this is a very cheap and simple method of producing the light. Messrs. Ladd & Co., who are the sole British agents, have exhibited it at their Shoreditch manufactory, terming it the "Workman's Lamp."

The Wallace-Farmer duplex dynamo-electric machine contains twenty-five coils set round the armature, each coil wound with four separate wires, the ends of which are brought up to an axial commutator, so that there are one hundred "makes and breaks" in one revolution. It can be worked up to 800 revolutions per minute, the power required to drive it being about one hundred revolutions per minute for each horse-power; each hundred, or each horse-power, being sufficient for one lamp. The armature, electro-magnets, and the work to be done are all in one circuit.

* "Telegraphic Journal," Nov. 7, 1878.

The Rapieff burner, now employed in the "Times" publishing office, shows great mechanical ingenuity, and presents the great advantage that it can be sustained for a whole night without change of carbons or attendance, and without alteration of intensity, as the current always passes through the same length of wick. This wick consists, not of two, but of four, pencils opposed to one another in pairs, the upper fed by the positive, the lower by the negative current. The four carbons form the figure X, except that the lower pair is set in a plane at right angles to the upper. As the points consume away, the carbons are made slowly to approach each other, so that the arc is always of the same width, and keeps its fixed position in space. They are directed towards each other over small pulleys by a counterpoise of about three pounds sliding down the stem of the instrument. In another form, the four carbons are all inclined to each other at a variable angle, and a cylinder of lime is supported over the light, which, becoming luminous, increases the illuminating effect by about 40 per cent. The Rapieff also places a safety apparatus under each regulator, which is simply an automatic arrangement for allowing the current to pass to the other lamps in the same circuit, should one lamp happen to become extinguished. There are six lamps in circuit at the "Times" office, but Mr. Rapieff has successfully exhibited as many as ten. The dynamic machines of Gramme are used as excitors.

The Werdermann light depends on a totally different principle. When in an electric lamp, electrodes having the same sectional area are used, the changes at the points between which the voltaic arc passes take place by a crater or hollow forming in the positive electrode which emits the light, the crater itself being heated by the current to white heat, and the surrounding part to redness. The negative electrode assumes the form of a cone, is only heated to redness, and emits scarcely any light. It is found, however, that an increase in the sectional area of the positive electrode diminishes the light emitted by that electrode; and if the increase be gradually continued, the light disappears entirely, while the heating effect upon the negative increases until it emits light. On the other hand, by increasing the sectional area of the negative electrode, the heating effect decreases proportionally to the increase of its area, until the heat almost entirely disappears, and the consequent consumption of that electrode is scarcely appreciable. The light given out by the positive electrode, on the contrary, increases in proportion to the difference between the sectional area of the two electrodes: and instead of a crater being formed in the positive carbon, this assumes the form of a cone such as before occurred to the negative. The greater the difference between the areas of the two carbons, the less is the length of the voltaic arc

between them, until at last the light is produced by carbons apparently in contact, and a small deposit of graphite is seen on the negative electrode. This deposit is about one-fourth the section of the positive carbon itself, and about one-eighth of an inch high.

Mr. Werdermann places the negative carbon, in the form of a disc, two inches in diameter and an inch thick, uppermost. It is clasped by a copper band attached to one terminal. The lower positive electrode is a small pencil of carbon, three millimetres in diameter, of any suitable length. It slides up vertically in a tube underneath the disc, projecting from it about three-quarters of an inch, this length being made incandescent when the current passes. It retains its point when burning. The carbons are kept in contact by chains passing over pulleys, and by a weight of about one and a half pounds pressing them gently into contact.

One of the most important elements in the economical consideration of the electric light is the motive power. The great objection which lay at the root of all earlier systems intended to utilise electricity either as a motive power, as in Jacobi's boat on the Neva, or as a source of light, was the expensive nature of the fuel required. The zinc consumed in the battery could only be produced at a cost which was practically prohibitory. The "Electric Light, Power, and Colour Company," started in 1855, endeavoured to evade this difficulty by using tin as the negative metal and utilising the refuse product for dyeing purposes. But this Company, though it brought out the excellent lamp of Mr. Chapman figured in the plate (Pl. II.), which contains the germ of many more recent patents, was commercially a failure and soon collapsed.

It was not until the invention of dynamo-electric machines had shown that motion, obtained without excessive waste, through the instrumentality of the steam-engine, from so cheap and abundant a fuel as coal, could be economically converted into electricity, that any financial comparison whatever between gas and the electric arc could be for a moment instituted. Even then there is an obvious disadvantage on the side of the latter, on account of the additional conversions of energy, with their attendant leakages in heat and friction, which it necessitates. Another difficulty, hardly if at all surmounted, now arises from the fact that electricity, as a source of light arising from intense and vehement action, is difficult to produce in moderate degrees, and hard to subdivide when once produced. It is not easy to realise in reading accounts of a light equal to 16,000 candles how far this is beyond the need of ordinary illumination.

The first idea as to motors which occurs to the mind is the utilisation of great stores of energy which are daily running to

waste in the form of rivers, cataracts, and tidal changes. It is remarkable that this mine of potential energy was early worked for illuminating as well as motor purposes by the mechanical instinct of a great engineer.

"A very important application of the electric current," says the "Daily Telegraph," "is now being carried out by Sir William Armstrong on his estate, about eighteen miles from Newcastle-on-Tyne. The power existing in a volume of water descending at the outfall of a Northumberland lake has been utilised by the interposition of a turbine, by means of which the requisite revolutions are given to a dynamo-electric machine. The electric current thus generated is conveyed through a stout copper wire to the private residence of Sir William at Cragside —a distance of about a mile and a half. The current is there conducted through a lamp devised on the Siemens plan, in which the regularity of the light is maintained by clockwork, subject to the control of an electro-magnet, which magnet reflects the strength or weakness of the current, so as to regulate the distance between the points of the carbon electrodes. It has been found necessary to provide a second wire to take the return current, so that the first cost of the light is somewhat large, but the working expense is very small. The light is used for illuminating the picture gallery at Cragside, and has proved eminently successful, not only in respect to the quantity of light afforded, but its purity of colour. In addition to this use of the electric current as a source of light, Sir W. Armstrong intends to avail himself of the power thus brought into his house, by applying it to several domestic purposes. This is to be accomplished by means of an electric engine situated in or near the house, and receiving the current transmitted from the machine at the lake outfall. In this way Sir William will be able to make a more constant use of what may be termed his electrical 'plant,' and thus may look forward to a satisfactory result in an economical respect. This example of the conversion and transmission of power will be viewed with great interest, the distance of a mile and a half being sufficient to indicate a much more extended sphere of action for the electric current than has hitherto been found practicable."

Immediately after hydraulic motors comes the steam-engine in one form or another. Mr. Shoolbred draws attention to the important point of regularity of motion, not only during each revolution, but also during successive revolutions. He notices the usual precautions of double cylinders, heavy fly-wheels, and sensitive governors. Where the motor power required is not great, that is, up to about 10-horse power, a gas-engine will be found convenient.

As regards the cost of the Electric Light, Mr. Shoolbred

read an instructive paper at the meeting of the Society of Arts, on December 5th. He stated that in every instance his figures and particulars were those afforded by the users of the various lights and not by the inventors or their representatives. In the case of the Holmes machine the annual cost per lighthouse was about £1,035, inclusive of interest, repairs, and wages. With the Siemens machine the annual cost was about £494 per lighthouse, including interest and the other expenses. With the Alliance machine, as used at Havre, the cost was about £474 per annum per lighthouse, interest, &c., included. The single-light Gramme machine has been in use in the Paris goods station of the Northern of France Railway for two years. Six machines have been kept going with one light each, and the cost is found to be 5*d.* per light per hour, or with interest on outlay at 10 per cent., 8*d.* per hour. The same light at the ironworks of Messrs. Powell, at Rouen, was stated to cost 4*d.* per light per hour, exclusive of interest and charge for motive power, the latter being derived from one of the engines on the works. In 1877 a series of experiments were carried out with the Lontin light at the Paris terminus of the Paris, Lyons, and Mediterranean Railway. The passenger station was lighted, and the results were so satisfactory that the company have entered into a permanent contract with the proprietors of the Lontin light for lighting their Paris goods station with 12 lights, at a cost of 5*d.* per light per hour. The Western of France Railway Company have had six Lontin lights in the goods station at the Paris terminus, St. Lazare, since May last, and 12 lights in the passenger station since June. Careful experiments have shown the cost to be 8*d.* per light per hour, inclusive of interest. Referring to the Jablochkoff light, Mr. Shoolbred placed before the meeting some particulars with regard to its application in the Avenue de l'Opéra, Paris, which were afforded him by M. J. Allard, the chief engineer of the lighting department of the City of Paris. It appears that the authorities pay the Société Générale d'Electricité 37f. 2c. per hour for the 62 lamps in use there. These 62 lamps supersede 344 gas-jets which were previously used, and which cost the authorities 7·244f. per hour. The electric illumination, however, is considered as equal to 682 gas-jets, or about double the original illumination—that is, to a cost of 14·45f. per hour as against 37·2f. for the electric light, the cost of which, therefore, is 2·6 times that of the gas. The contract for lighting by electricity was terminated by the City of Paris on the 30th of November, and the authorities have declined to renew it except at the price paid for gas—namely, 7·244f. (or nearly 6*s.*) per hour, and that only for a limited time. These terms have been accepted by the Société, so that the price paid

to them will be at the rate of about $1\frac{1}{8}d.$ per light per hour. Mr. Shoolbred stated that the Société place their expenses at 1·06f. (or just 10*d.*) per light per hour, which, however, they hope shortly to reduce by one-half.* A series of careful photometric experiments carried out by the municipal authorities with the Jablochkoff lights, above referred to, showed each naked light to possess a *maximum* intensity of 300 candles. With the glass globe this was reduced to 180 candles, showing a loss of 40 per cent., while during the darker periods through which the lights passed the light was as low as 90 candles. The foregoing were the only authenticated particulars which Mr. Shoolbred could obtain as regards the working of the various systems of electric lighting. In conclusion he referred to the Rapieff light at the 'Times' office, which, he observed, worked fairly and with regularity, which could not be said of all others, and it might therefore be entitled to take rank as an established application of electric illumination.

"The practical illustration," says Mr. Siemens in an excellent letter to the "Times," "of the power of the electrical conductor serves to show the possibility of application upon a large scale such as I have ventured to suggest. A true comparison between the cost of the electric current and its rival, gas, cannot be instituted until central motor stations are established in populous districts, where steam power may be produced at the cheap rate of two and a half pounds of coal per horse-power per hour, and whence radial conductors may supply the neighbour-

* Mr. Stayton's very sensible report to the Vestry of the Parish of Chelsea points out that a 16-horse power engine in Paris supplies 16 lamps, exactly one-horse power per lamp; that the candle itself costs $7\frac{1}{2}d.$, and burns an hour and a half, being automatically replaced without visible interruption. The intensity of the light is 700 candles without, and one-third less with the globes; the ordinary London street lamp only equalling 12 to 15 candles. Each light, which only burns from dusk to midnight, costs 1fr. 45c., *i.e.* 1*s.* $2\frac{1}{2}d.$ per hour, the general cost being four times that of gas, but that a greater amount of light is obtained. Paris, it appears from the same report, is already much better lighted than London. To adopt the electric light to Sloane Street, which is 11,000 yards long and 20 wide, would require two stations with 16-horse power engines, and other machinery costing 3,200*l.* The cost of maintenance of candles, &c., would be 16 shillings per hour for an average of 3,250 hours per annum. The gas lamp now costs $8\frac{1}{2}d.$ per hour. To light the Chelsea Embankment would require an outlay of 4,800*l.*, and an hourly cost of 1*l.* 4*s.* 0*d.* The present cost is 2*s.* $1\frac{1}{2}d.$ per hour. Sloane Street, however, would be 31 times brighter than at present, which, by the way, it might well be with advantage to wayfarers. He shows that the conveyance of electricity involves enormous loss; that a little is saved by instantaneous lighting and extinguishing, that the light is safe for horses, powerful, innocuous, free from heat, but on the whole *not* suitable for street lighting, though it *is* suitable for large spaces such as Trafalgar and Parliament Squares. We entirely agree with the worthy engineer.

hood within, say, a mile radius, with both light and also with mechanical power for minor industrial purposes. The realisation of such a system involves the means of subdividing the electric current to a certain extent, a problem which offers no insuperable difficulties when continuous currents are used instead of the reversing currents which have hitherto been mostly resorted to for street lighting."

The probable uses and applications of the electric light are now becoming tolerably definite. It is clear that for extensive areas and large buildings it is of great beauty and value. To this employment of it there is, however, one drawback, namely, the intensity and apparent solidity of the shadows it throws. During the work below the level of the Thames in laying the foundations of the railway bridge at Blackfriars, it was for a time extensively used, with a view of continuing the work at night. But it was ultimately discontinued on account of the numerous accidents it entailed, from the workmen mistaking such shadows for the passage-boards leading to the bottom of the cofferdam, and endeavouring to wheel their loaded barrows upon them. If this difficulty, which arises chiefly from the great intensity and point-like character of the incandescent arc, be obviated by diffusing the light within a semi-transparent globe of opal glass, from 30 to 40 per cent. of the light is lost, and the effective cost of the light proportionally increased.

Many further improvements seem likely to be effected before long. Besides the threatened discovery of Mr. Edison, which appears to be taking a practical form, the Sun Electric Light Company, who lately addressed a communication to the Metropolitan Board of Works, have acquired certain patents, among the more remarkable of which is one for the manufacture of flexible carbon. The value of flexibility for a carbon electrode is obvious. If a strip of carbon can be wound and unwound like a piece of india-rubber, or with some fair approximation to that degree of pliancy, facilities are afforded for stowing away a long length of carbon in a small space under the electric lamp, thereby providing for a combustion which shall last a considerable time. How far this end is attained remains yet to be seen, and the Company have other patent lamps besides those in which the flexible carbon is to be employed. The Company have entered into arrangements for a trial of the electric light at the Crystal Palace. A 12-horse power steam-engine by Ruston and Proctor will be provided by the Crystal Palace Company, and a shed for its reception will be erected at the main entrance to the building, opposite the high level station. A Gramme machine to generate the current will also be placed at this spot, and the arrival of the machine from Paris is expected daily. The machine will be a small one, and is reckoned to require only $2\frac{1}{2}$-horse power to

drive it. If the experiment answers, it is anticipated that the entire Palace will be lighted up in the same manner. At first there will be only four lights, each fixed at an elevation of sixty feet above the main floor of the Palace, at the angles of the large open space under the central transept. The current will be transmitted by wires, each about one hundred yards in length, laid under the floor of the building, and converging into a special apparatus, whence other wires will proceed to the several lights, each light having its own pair of wires proceeding from the apparatus. A trial of the light, under the auspices of the same company, is also about to take place on the premises of a firm in the City. Arrangements are likewise pending for lighting up one of the large railway stations in London, and the Agricultural Hall at Canterbury.

The present excitement on the subject of the electric light occasions a great demand for the Gramme machine. Patent rights and royalties, backed up by Chancery proceedings, create some degree of obstruction in the use of dynamo-electric machines, and occasion delay in the development of processes for regulating the light. The lamp is one thing, and the machine for generating the current is another. In some cases the use of galvanic batteries is contemplated as a substitute for a machine, where only one or two lights are required. Another essential is that of the motive power by which the dynamo-electric machine is to be driven. Sir W. Armstrong's use of water-power for this purpose is very instructive and encouraging. The suitability of gas-engines to drive the dynamo-electric machine is so generally recognised, that a great demand has sprung up in consequence, and, according to some accounts, there is a difficulty in getting orders executed for the delivery of these motors, thereby giving rise to another source of delay. These obstacles in themselves stimulate invention, and it is not unlikely that some new form of dynamo-electric machine will ere long be placed before the public. The Meritens machine, lately invented in France, is stated to develope more power than the Gramme machine, in the proportion of three to one. That is to say, the Meritens machine is credited with maintaining one Jablochkoff light by the expenditure of one-third of a horse-power. On the other hand, the cost of this machine is high, being nearly double that of a Gramme comparable to it in size. The French patent for the Meritens machine is understood to have been sold for a very large sum. It may be safely asserted that there is no finality in respect to electric light inventions; and there is little doubt that many new devices, with several startling changes, will present themselves in this domain of science within a brief period of time. The Patent Office is still besieged with inventors engaged in perfecting the electric light or its accessories, and among

these people are several eminent scientists, whose efforts are not likely to be misdirected.

Among the more recent developments of electric lighting is the electric light of Mr. Van der Weyde, ordinarily utilised by him for photographic purposes, to which he was the first to apply it. It is not the production of the current nor the means of converting it into light at which Mr. Van der Weyde has laboured so much as the rendering of the light produced available as an illuminator without wasting it, so to speak, and yet without throwing the rays directly upon the object to be illuminated. His apparatus and arrangements may be described as follows:— In the basement of the house is an Otto silent gas engine of eight-horse power, which works steadily and well and without needing any attention, save at starting and stopping, goes on hour after hour driving either one or a pair of Siemens' dynamo-electric machines, as may be required, the machines producing continuous currents. The current thus produced is led up to the burners which are placed in the various studios, and which consist of two carbon rods placed vertically one over the other, the light being produced between the points. The upper rod is three-eighths of an inch in diameter, and the lower one three-quarters of an inch, and these are placed near the mouth of a concave reflector lined with white material. None of the rays of light reach the spectator direct; they are intercepted by a disc of opal glass about four inches in diameter. The whole body of the rays is gathered up in the reflector and thrown out in a flood of pure white light, in which the most delicate shades of tint are distinctly discernible. At present the consumption of the carbons is followed up by hand-adjustment, that being most convenient for photographic purposes. For general illumination, however, Mr. Van der Weyde proposes a mechanical arrangement. In fact, it does not affect his principle whatever apparatus for burning he uses; he can take the Serrin or the Siemens lamp, the Jablochkoff candle, or any other suitable arrangement. His principle consists in cutting off the direct rays from the objects to be illuminated, and surrounding them only with a white cloud of light. Mr. Van der Weyde is now engaged in a modification of his system, which will shortly be seen in an improved form in Regent Street. As regards expense, we have here some exact data afforded by the six hours during which the light was publicly exhibited on November 9. Long use of the Otto gas engine has shown Mr. Van der Weyde that the cost of the gas for it is exactly 6*d.* per hour. A pair of carbons costs 2*s.* 6*d.*, and a pair was consumed during the experiment. This gives a total of 5*s.* 6*d.*, or exactly 11*d.* per hour per light. But it is to be observed that during the experiment the second machine was at times running, so that some deduction should be made on that account. In fact, only half the power—

that of a four-horse engine—would be required for one machine, so that the cost of production would be thus reduced These calculations are, of course, irrespective of first cost of plant and machinery and of interest on capital; but they serve to show approximately the working cost of this light.

Another worker in the field of electrical science, who is at present pursuing his investigations with a view to demonstrating the indefinite division of the electric current is M. Antoine Arnaud, his patents not being yet quite completed. M. Arnaud appears to have succeeded in dividing and controlling the current, so far as experiments on a small scale are concerned. He has shown that a large number of lights can be maintained in one circuit, and that the extinction of any of the intervening lamps had no effect upon the remainder. M. Arnaud expects to be able to light a thoroughfare with a number of lamps, giving an uniform light throughout, and without fear of the extinction of one or more affecting the rest. Mr. Wilde, whose name is already honourably known in connexion with electro-dynamic machines, has introduced an ingenious simplification of the Jablochkoff candle, which dispenses with the intervening kaolin or plaster diaphragm. In a paper read before the Manchester Literary and Philosophical Society he had already pointed out the fact that when the electric light is produced from the ends of two carbon pencils placed parallel to each other the carbons will burn steadily downwards from the top until they are wholly consumed, without any insulating material between them. It was observed that even when the circuit was completed at the bottom of a pair of carbons close to the holders the arc immediately ascended to the points and remained there. This occurred in whatever position the carbons were placed. Two rods are therefore placed side by side, one being fixed, the other hinged at the base, and pressed gently against it by a spring. Directly the current passes the spring is overpowered by an electro-magnet in circuit, which separates the movable rod to the proper distance from its fellow. The need for a "priming" to start the arc is thus simply superseded.

DESCRIPTION OF PLATE II.

Chapman's Electric Lamp. Specification dated A.D. 1855, *April* 3, *No.* 739.

A. Gravity holder for upper carbon, controlled by
B. Brake-wheel and brake; the latter being actuated by
C. An electro-magnet, on closing the circuit.
D. Second electro-magnet, causing a separation between the carbons, and establishing the arc.
E E. Terminals to battery.

BRITISH MEAN TEMPERATURES.

By W. L. DALLAS, of the Meteorological Office.

IN the Himalayas, the Andes, and other great mountain chains within the tropics, a phenomenon may be witnessed which is always interesting and instructive. A traveller climbing one of these ranges advances first across valleys and small hills covered with the jungle and luxurious vegetation of the tropics. As he continues the ascent he leaves behind him the beautiful palms and immense cotton trees, the brilliantly marked birds, reptiles, and insects, the inhabitants of the tropics, and reaches the oak, the elm, and the birch, the growth of the temperate zone. These, in their turn, give way first to the larch and the fir, then to low bushes and scrub-wood, then to lichens and mosses, and finally to the region of perpetual snow. The whole of the flora and fauna have changed. Even in this short time a journey has in reality been effected from the equator to the pole; yet the lie of the land is the same, and the air is the same, the whole atmospherical conditions are only slightly modified, with one great exception—and that exception is, temperature.

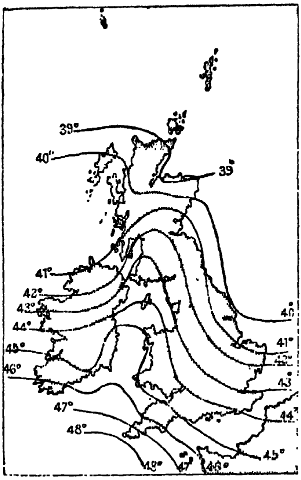
Difference of temperature is thus shown to be sufficient to gather the products of all the different zones of the earth into one small region, demonstrating practically and plainly the importance of temperature to every inhabitant of this world. Any contributions, then, which are made to our knowledge of this the most important factor in climate, must deserve and receive interest and attention from every one. More particularly is this the case when the contribution is made by the Meteorological Office, as in the case of the recently-published Tables; for, coming from such a quarter, it carries a guarantee that the observations have been taken with that regard to uniformity both of instruments and exposure which is so necessary for a proper comparison of the temperatures of different places. Instructions for taking temperature observations have been prepared; and in many cases every effort has been made to secure uniformity in the hours of observation, the nature of the screen, and in the instruments from which the observations are to be

taken. But, whatever the method of observation may be now, it can scarcely be disputed that in former times there was a margin for improvement; so considerable, in fact, that it is difficult to understand how to accept the present arrangements as approximately correct, and yet regard the previous observations as having any claim to scientific accuracy. Everyone can understand how, when it was left to the discretion and taste of amateur meteorologists to employ screens of any shape and position they pleased, the vagaries and opinions of the different workers should have led to an endless variety of form and exposure. It can, therefore, occasion no surprise to read in one of the publications emanating from the Meteorological Office that at the time of the first inspection of stations it was found that thermometers were placed in some cases under station roofs; that at one place the wet bulb had never seen water for about three weeks, while in another it had been completely immersed in that element for about the same period. All these sources of difference having been eliminated, and uniformity of exposure and time having been obtained, it must be evident that these observations may be regarded not only as the latest but most correct data to be obtained of the temperature of the different parts of these Islands.

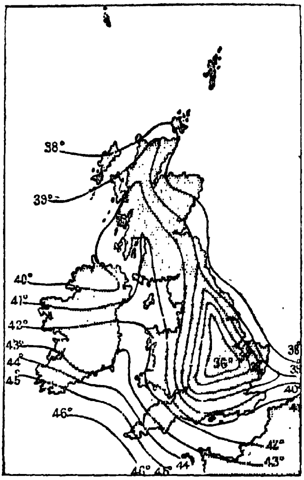
The best and plainest method of displaying quickly and clearly the general distribution of mean temperature over our Islands is to plot the observations on charts, and the following figures give the isotherms for each of the twelve months.

January.—The influence of the waters of the ocean, and more particularly those of the Atlantic, in modifying climate, has been repeatedly pointed out, and this influence is clearly shown in the January chart. The warmest station in the British Isles in this month is Scilly (48°); for not only is it the most southern point of our coasts, but it is surrounded on all sides by the heat-bearing waters. Next in order after the Scilly Islands come Valentia, on the south-western promontory of Ireland, and Plymouth (both 46°), both stations well exposed to the warm south-west winds and the open sea. From this warm south-western region temperature gradually decreases in a north-easterly direction, and reaches its lowest point (39°) on the coasts of the Moray Firth. Although this is actually the coldest part of the kingdom, it will be noticed that the temperature of the whole of the east coast of England is very little more genial; the isotherms, after having been carried well to the northward on our western coasts by the influence of the warm Atlantic, turn almost at right angles in a southerly direction till they come to a region which is again, though in a more modified degree, heated by the waters of the ocean, viz. the shores of the English Channel, when they again take a more easterly course.

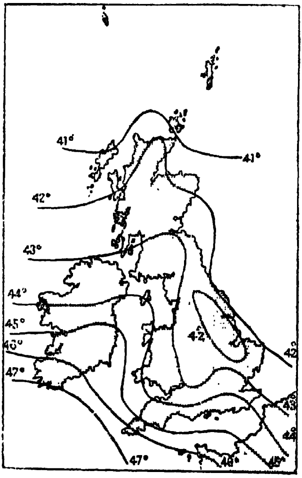
1. JANUARY.



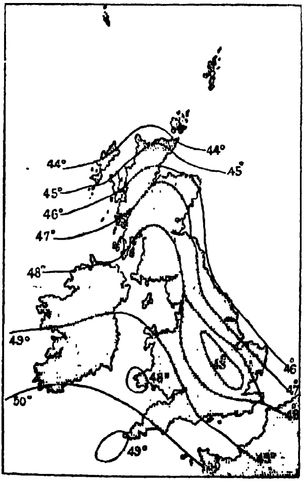
2. FEBRUARY.



. MARCH.



4. APRIL.



February.—The main characteristics of the January isotherms are again seen in the February chart; the temperature readings are shown gradually decreasing from the Scilly Islands (46°) to the north-east of Scotland (38°), while the same sharp angle southward is observable in many of the isotherms. But it will be noticed that, so far from the coldest region being now the coasts of the Moray Firth, a narrow band of still lower temperature is shown stretching across south-eastern and central England.

March.—This chart shows a general increase of warmth; and this being greater over central England than elsewhere, readings are more uniform, and the isotherms more regular. A small area of low temperature is, however, still shown over the northern and central parts of England, York having the same mean temperature as Stornoway and Wick, while the isotherm of 42° runs southward from Thurso through Aberdeen, Shields, &c., as far as Cambridge and Yarmouth.

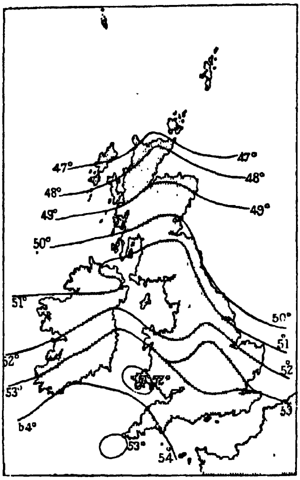
April.—The influence of the sea is beginning to be shown operating in the opposite way to that which we have observed in previous months, while the sun begins to exercise considerable influence on the land. Scilly is not so hot as the mainland stations of Cork and Plymouth, while the comparative coldness of the northern islands is shown by the crowding together of the isotherms over the northern part of the mainland of Scotland. At the same time over that part of central England where formerly we found a cold region, the sun now possesses sufficient power to raise the day temperature to a height which produces a mean temperature superior to that of the surrounding districts. The more eastern parts of England are still cold, the isotherms having still a north and south direction on our east coast.

May.—A further general rise of temperature occurs during this month, amounting, as a rule, to about 3°. Cork and Plymouth again show the maximum mean temperature, but the isotherms are not so crowded together in the north of Scotland.

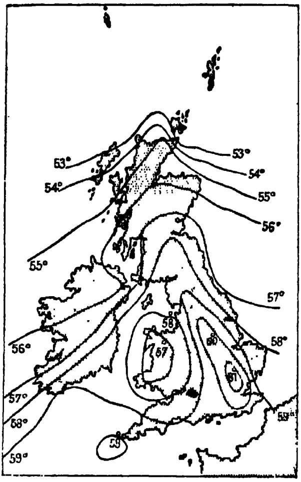
June.—A rise is shown over the whole country, the mean temperature now varying from 61° in the south to 53° in the north. Over the greater part of the country the increase is about 5°, but over central and southern England it amounts to as much as 8°. The hottest district is that around London, whence a narrow band of high readings extends northward over central England. It will be observed that all the isotherms send a narrow promontory northward over the central stations, showing the influence of the sun in raising the heat of the inland stations, and that of the sea in tempering the heat of the coast.

July.—A further rise of 3° or 4° is shown; but otherwise no great change has occurred, the relative distribution of the isotherms being very similar to that of June. July is the hottest month in the year.

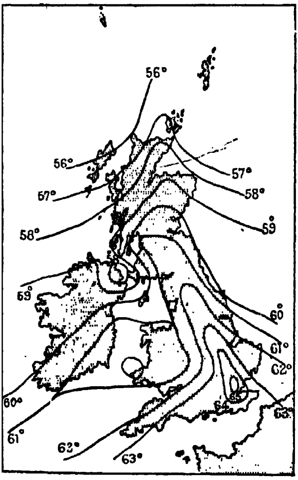
5. May.



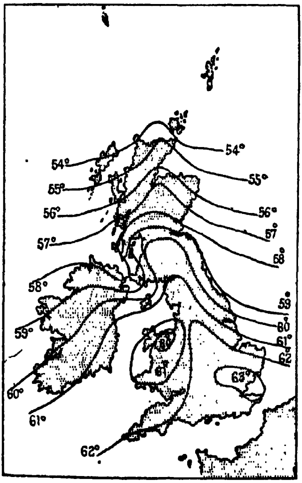
6. June.



7. July.



8. August.



August.—Temperature now begins to decrease again. A fall of one or two degrees is noticed both in the Thames valley and in Scotland, but the changes elsewhere are unimportant. The northern islands of Scotland appear to be getting colder, as the isotherms are again crowding together over North Britain.

September.—A fall of 3° or 4° has taken place over the whole country. The isotherms are more uniform and regular in this month than any other, though there is still a slight ridge to the northward over the central stations.

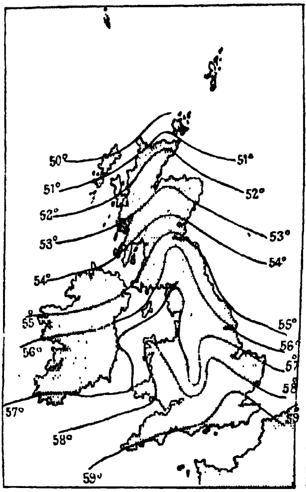
October.—A rapid fall has occurred amounting to 5° or 6° in the north and to 8° or 9° in the south. The warmest place is once more the Scilly Islands; while, owing to the excess of decrease in the south as compared with the north, the isotherms are becoming wider apart, and the chart is acquiring more the appearance observed in the spring.

November.—The thermometer shows a further decrease, though the difference between November and October is not so great as that between the last-named month and its predecessor. The warmest point is still Scilly. The isotherms turn sharply southward over England, and a small region of low temperature is appearing over the central parts of the country.

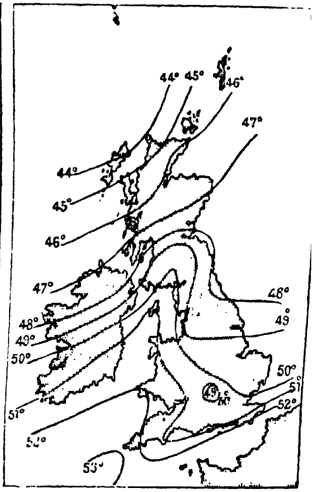
December.—A further decrease has occurred everywhere; but the change is again greater over the central stations than in the west and north, so that the cold region has become much more pronounced. This chart affords an excellent example of the rapidity with which temperature decreases as we travel inland from the western coasts, the isotherms between Holyhead and Nottingham being exceedingly close together. The temperature of this month bears a very close resemblance to that of February, though at some stations February is the colder of the two.

As we have advanced through these charts, numerous instances of the influence of the sea have been mentioned; but its power is much more noticeable when discussing the maximum and minimum observations than when dealing with the means of such readings, the great difference between what are termed continental and insular climates lying in the large range of temperature in the one case as compared with that in the other. Taking, then, a mean of the maxima and a mean of the minima, we much more readily realise the sort of climate which prevails at a given station than if we confine our observations merely to the mean temperature. Within our islands it is of course impossible to show any very extensive range in the thermometer, the climate, though varying somewhat in degree, being thoroughly insular over the whole country. Thus no station within our limits has a climate anything like that of Quebec, which, lying in the same parallel as central France, enjoys summers

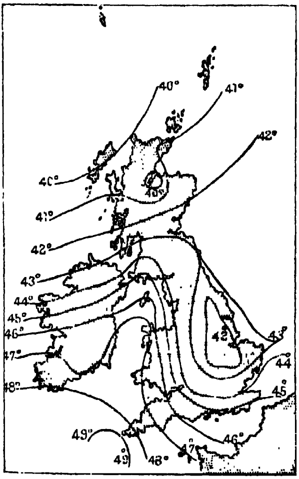
9. SEPTEMBER.



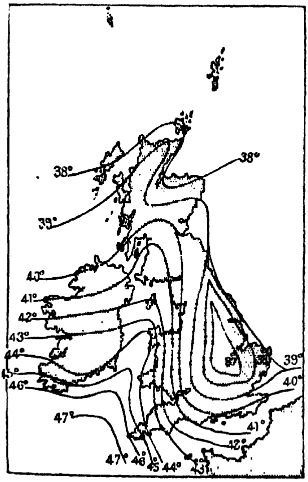
10. OCTOBER.



11. NOVEMBER.



12 DECEMBER.



as warm as those at Paris, and experiences winters as cold as those at St. Petersburg. Nevertheless a comparison of the maximum and minimum readings will show that within the narrow compass of the British Isles the phenomena of continental and insular climates are, though on a very small scale, as distinctly to be traced as on the great continents of Asia and North America.

If we take the mean maximum of the hottest month of the year, and the mean minimum of the coldest month of the year, the difference will show the average annual range of temperature at the different stations. Arranging them in threes from west to east, as nearly as possible in the same parallel, we find :—

	July Mean Max.	February Mean Min.	Range
Stornoway	62°	33°	29°
Nairn	66°	34°	32°
Aberdeen	65°	34°	31°
Moville	64°	37°	27°
York	71°	31°	40°
Shields	66°	35°	31°
Valentia	65°	40°	25°
Nottingham	74°	31°	43°
Yarmouth	68°	34°	34°

From these figures it will be seen that on both sea-coasts the climate is eminently insular; while over the central parts of the country it is in a slight degree continental. The difference would be still more marked were the waters of the North Sea as equable in their temperature as those of the Atlantic.

The remaining portion of the tables just published deals with observations which, though interesting, are of less importance than the observations we have just been discussing. They are the extreme temperatures which have been experienced over the country during the whole period over which the observations extend. They are interesting as showing to what degree of heat or cold we are liable; and in some cases no doubt this might be important; but it is impossible to give any summary of the results. The readings show, however, to what a very large range of temperature the central parts of the country are subject, notwithstanding the favourable position of these Islands, the thermometer carefully shaded and exposed having, during the three or four years under discussion, risen at one time to 91°, while at another it has fallen to 10°, showing a range of 81° in the short interval of five years.

The mean temperature given above must be regarded by the agriculturist and the farmer in a very general and liberal spirit,

as giving only the main characteristics of the mean monthly temperature over our Islands. So soon as details are entered into it will be found that in contiguous districts considerable variations are occasioned by purely local influences, such as the lie of the land, the drainage, the amount of wood in the neighbourhood, and the quality of the soil. For instance, in the Thames valley the general surface clay is pierced in several places by the sandy, gravelly stratum which underlies it; and observations of the temperature of the air, made simultaneously over the different soils, would probably give very different results. After a shower of rain the water would soon disappear from the loose sandy soil, and the sun's rays would immediately heat the earth and the superincumbent layer of air; while on the clay the water would remain and keep the temperature down. Thus, while the isotherms on the different charts give the main distribution of temperature, due allowance must be made for such local influences as have been described above. The different cereals with which a farmer is principally concerned, though showing considerable climatic adaptability, are yet very sensibly affected by the temperature, and their profitable cultivation can only be carried on within strictly defined limits. Thus, wheat cannot be grown with profit in the north of England at a greater elevation than 700 feet above the mean sea level; and in the Orkneys, though it has been repeatedly tried, and generally produces an abundance of straw, the grain is seldom of any service. Oats, rye, and barley show a much wider geographical range than wheat; but neither oats nor rye can be grown profitably in the Farö Islands, and though barley is still cultivated there the success is very limited. This is due to the strictly insular character of the climate of these Islands; for in Norway, in lat. 71°, or about 10° lat. further to the northward, both barley and rye grow freely, adapting themselves to the short, hot summer which prevails on the Continent in those latitudes. In fact, such is the speed with which vegetation progresses in situations from which during the summer the heat and light of the sun are scarcely ever withdrawn, that sixty days is the ordinary interval between sowing and reaping.*

To the doctor a knowledge of the climate of the different parts of our Islands is of immense importance as determining the health resorts most suitable to the various patients under his care. It appears from statistics that the moist, equable climate which characterises the west coasts of Ireland and Scotland is much more healthy than that of England, and still more so than that of the continent of Europe; so that the percentage

* Morton's "Cyclopædia of Agriculture."

of deaths increases as the coast is left behind. A continuously cold or a continuously hot climate it is possible to endure; but great extremes, following each other in quick succession, immediately cause an increase of the death rate in the Registrar-General's return. The very cold winter which occurred in 1860 occasioned as many deaths as a severe visitation of cholera; and the death rate for the different diseases increases or decreases in a perfectly regular manner according as the climatic conditions are favourable or unfavourable to each particular disorder. Dr. Williams, in his little work on the "Influence of Climate on Consumption," mentions that the natives of Tahiti are liable to an exceptionally malignant form of that disorder, and shows that it is due purely to climatic influences peculiar to those islands, and not to the physical organisation of the natives. To prove this he quotes the fact that during the time the French frigate "Serène" was in port there, many of the sailors were attacked by a similarly severe form of consumption: that twelve died, and many others had their lungs affected. On the other hand, the same writer mentions that a Swiss who was domiciled at Panama, and who was attacked by a very severe form of consumption, regained, on ascending the mountains as high at Quito, all his former health and strength, only, however, to lose them again on his return to his old quarters. These two experiences prove the influence which climate exercises on the progress of disease, and the great importance of medical climatology. It will be plainly seen that, in the case of the British Isles, to patients living in the north and who during the winter require a warmer climate, the mere journey southward would be of no avail, without a corresponding movement in a westerly direction, because during the winter months the temperature of eastern and central England is at least as low as that of the east of Scotland, and during some time of the year is even lower; while, to improve upon the climate of the west of Scotland, it would be necessary to go to the extreme south-western coasts of England. In addition to this it is proved, by an investigation of the Registrar-General's returns, that no sooner does temperature fall to a certain *low* point than the death rate among patients afflicted with certain complaints immediately increases, while so soon as it reaches a certain *height* the mortality from certain other diseases increases. It consequently follows that the inhabitants of central England, where the weather is colder in winter and hotter in summer than elsewhere, are liable to more diseases than the inhabitants of the western part of the country, always supposing, of course, the other conditions to be equal. Messrs. Buchan and Mitchell of Edinburgh, in a singularly exhaustive and interesting paper, have traced the con-

nection which exists between disease and temperature, and have shown by means of curves, drawn according to the percentages of deaths above or below the mean number for the year, the oscillations which occur as the weather changes. Some of these curves, which have been drawn for all the disorders for which the Registrar-General's returns furnish data, are exceedingly well marked.

The curve for diseases of the respiratory organs shows a maximum during the first two weeks of January, and a minimum in the last two weeks of August; while the curves for dysentery, diarrhœa, and cholera show that during the greater part of the year deaths from these causes are very much below the average for the year; but that during July, August, and September the percentage of deaths above the mean increases with frightful rapidity. These are the most strongly marked of the curves; but, in nearly all, some relationship may be traced between the climate and the number of deaths. Even suicides, murders, and homicides, as well as such diseases as delirium tremens, show that they are amenable to certain climatic influences, and exhibit regular periods of maximum and minimum intensity. Of delirium tremens, Messrs. Buchan and Mitchell say: "Deaths from this cause have a well marked annual curve—it rises above its average in the middle of May, attains its absolute maximum in the latter part of July, thereafter falls to the average in the last week in September. Its absolute minimum is during the first half of December; and it continues below the average from October to the middle of May, with the singular exception of the Christmas and New Year period, when there occurs a short continued secondary maximum." This secondary maximum is probably due to disturbing influences other than the weather.

Such are the main characteristics of the temperature of the British Isles for each month of the year; and it only remains to say that the means from which this paper is compiled are those just published in the "Quarterly Weather Report," pt. 3, 1875; that they are derived from the maximum and minimum observations made at different stations over the country; and that they extend, *as a rule*, over a period of four years. Such a period is, it is well known, generally considered to be too short for the deduction of perfectly reliable temperature means; but whatever deficiency the present observations have in regard to length of time, is probably largely compensated for by taking into consideration the fact that they refer to a period which has only just passed, the superiority of the instruments used, and their better exposure and uniformity. Besides, in addition, it has been proved by incontestable evidence that every marsh that is

drained, every wood that is cut down, and every bog that is reclaimed exercises a great influence on the climate of the country in the immediate neighbourhood; so that, having regard to the great improvements of the soil which are in progress on all sides, it must be evident that, even in the short period that has elapsed since the last of these observations was taken, modifications may have arisen which, before many years are over, may cause the present means to be very far from representing the actual temperature of our Islands.

THE ORIGIN OF TARNS.

By the Rev. J. CLIFTON WARD, F.G.S., F.R.M.S.

WHO has not felt a sudden and intense pleasure when, rounding the end of some mighty mountain or towering crag, the still waters of an upland lake or tarn have first met the eye? Perhaps, on approach, wild birds have started from the smooth surface and left it a little sea of shimmering gold, as the sun's light has been reflected from each tiny wavelet. The raven's croak among the overhanging cliffs, the patch of snow lying unmelted deep in a rocky fissure, the scattered sheep browsing carelessly on the few grassy slopes, while all around are masses of tumbled rock, and the light veil of cloud that ever and anon sweeps the cliff tops and adds an air of mystery and wonder to the whole—all combine to make a scene which cannot but send a thrill of pleasure and perhaps of happy awe to every heart. Instinctively one feels, if the power of expression be not present, what nature's true poet hath so truly sung.

> How divine
> The liberty, for frail, for mortal man,
> To roam at large among unpeopled glens
> And mountainous retirements, only trod
> By devious footsteps; regions consecrate
> To oldest time! and, reckless of the storm
> That keeps the raven quiet in her nest,
> Be as a presence or a motion—one
> Among the many there.

No one can wander over rugged and beautiful mountains without being led to love and admire these calm sheets of water, which lie nestled in hollows, and are ofttimes blackened by the shadow of encircling cliffs. Love for such solitary spots soon excites our curiosity as to the origin of these miniature upland lakes. In the Cumbrian lake district they are scattered broadcast over the country in far greater numbers than most people imagine, and at a period not vastly remote their number must have been more than double what it is now. But the

yearly waste of mountain side and the matter brought down by every stream have filled up many a mountain pool, and frequent peat mosses mark the spot where once the waters danced in the mountain breeze. Whence these hollows? What is their origin? Do we see in them the relics of volcanic effort? Are the combs (cwm), coves, or corries in which they lie the vestiges of volcanic craters, as the form of many at first, perhaps, suggests? Or have we here hollows produced directly by surface action? Again, are these hollows of great depth, or are they shallow? What is their general form? Now, there is little doubt that most people, if asked to draw the form of the hollow in which the waters of a tarn now lie so placidly, would grossly exaggerate its true depth, or, perhaps, liken it to the basin formed by placing the two hands together, side by side, curved, with the palms uppermost. Some years since I took a number of soundings among the Cumbrian lakes and tarns, and communicated the results of my examination to the Geological Society (Quart. Journ. Geol. Soc. vol. xxx. p. 96, and vol. xxxi. p. 152). Hold out one hand, palm uppermost, and straighten it as much as possible—the hollow in the palm is yet far too deep to represent with truth the natural rock basin. Soundings taken in lakes throughout the district all show the same thing—the basins are very shallow compared with their size and the height of the surrounding hills.

Next, let us search out the origin of these shallow basins. At the outset we distinguish two classes of action, one of which must have been at work. Either the matter formerly filling the hollow has been dug out and carried away by some agent working at the surface; *or* force from below has here sought a vent, and dispersed the matter far and wide; or, from failing support, the ground has sunk at this spot into a hollow.

First we will consider the upward or downward theory. If these numerous mountain hollows with included tarns be of volcanic origin, then it is clear we shall find the *signs* of a crateral hollow such as we see them in many parts of the world at the present day. There are no such signs. It is true that in many cases the surrounding rocks are of volcanic origin; but the volcanic beds, in their lie and position, show no manner of relation to the tarn hollows; and a little study of the rocks of the district and the form of the ground clearly shows that the volcanoes which gave rise to the ashes and lavas forming many of Cumbria's highest mountains, were active, not as but yesterday, but in untold ages past. Then, as to the *downward* or *special depression* theory, when we can conceive such minute subsidences taking place at a great number of almost microscopic spots without affecting the rocks around, or leaving any evidence of a sinking away, we may admit it as possible.

If not produced by expulsion of matter outwards or sinking of matter inwards, these hollows must be the effect of some surface-working agent. The sea *planes* away along the coast-line, and the material goes to *fill up* ocean hollows; therefore the sea cannot be the agent, and any force in an ocean *current* is clearly out of the question over these scattered *spots*. Streams and rivers work along lines, form ravines and gorges, but never a more or less circular basin of great size in comparison with the stream, or river; hence they cannot be the agents. The atmospheric powers—rain, snow, wind, and chemical action—weather the rocks indeed, form tiny basins on almost every stone; but this is but nature's fretwork, the delicate carving around the sculptured craggy tower or spire and smooth-scooped rocky front. Yet there is one surface agent remaining, the moving glacier. Most people are familiar with the proofs of former glacial action in Cumberland and Wales—proofs as clear as are those of the former greater extension of the Swiss glaciers. Now by far the greater number of our tarns lie in true rock basins—hollows completely enclosed by rocky sides, which are, moreover, smoothed and grooved in a manner peculiar to ice action. At the sides of many a tarn and lake you may see the ice grooves and scratches passing beneath the water, so as to leave no doubt whatever that ice has once occupied the rocky hollow. The question is, Did the ice movement form the hollow? I believe that in most cases it did, and for these reasons: 1. The tarns lie almost invariably in the path of old ice streams or glaciers, as is proved by the direction of the scratches in the surrounding rocks. 2. They *frequently* occur at the foot of slopes more or less steep, or where the ice pressure can be shown to have been great. 3. The position of the deepest points in the larger tarns and lakes occurs almost invariably where, from the confluence of two or more glaciers or the narrowing of the valley, the ice pressure must have been somewhat increased. 4. The depth of these tarns is very slight as compared with the thickness of the ice which can be proved to have passed over them. 5. There is every gradation from a tiny rock-bound pool, glaciated on all sides, and which all will admit must have been scooped out by the ice, to the tarn or lake showing precisely similar phenomena on a larger scale.

Since the ice plough passed over our land the atmospheric powers have been at work for a long period, and while many rock basins are now completely filled up by stream-borne matter, all are *being* so filled, and each age must witness a decrease in the number and size of those sheets of water which form so marked a character of our Cumbrian scenery.

Before quitting this subject, however, I must remark that there are a few tarns which seem to me to owe the whole or a part of

their depth to a moraine dam. That is to say, the rock basin is imperfect on one side, and there an old glacial moraine may have helped to dam the waters back ever since the retreat of the glacier which threw off the moraine. It frequently happens that a little moraine material has been left upon ice-rounded rocks at the foot of a tarn, and in such cases a hasty observation might lead one to believe that the whole mound was a moraine. Let us remember, then, that a tarn may lie in a complete rock basin, ice-formed; in a glaciated hollow dammed on the lower side by a moraine or other accumulation of rocky débris; or it may owe part of its depth to a rock-enclosed hollow, and part to a morainic dam. Therefore, on a summer's day, as we lie dreamily gazing upon the rippling waters of these mountain tarns, we may sometimes think of an age which is past, when the ice-sheet moved majestically over the now heather-clad fells, and all the country lay "clad in white samite, mystic, wonderful."

ON THE EXTENT OF THE GAP BETWEEN CHALK AND EOCENE IN ENGLAND, AND ON SO-CALLED UPPER CRETACEOUS FLORAS.

By JOHN STARKIE GARDNER, F.G.S.

MOST of those possessing even but a superficial acquaintance with geology in England are aware that the Eocene strata in this country invariably rest, often conformably, upon the Chalk. Those who have collected fossils from the rocks above and below the Chalk are familiar with the complete change in the fauna belonging to each. The thoroughness of the change is recognised in the fact that from the Chalk downwards the rocks are considered to be *Secondary*; while strata above the surface of the Chalk are recognised as *Tertiary*. Although frequently but a slightly eroded surface and a few water-worn flints actually separate them, a vast interval indeed separates them in geological time. So immense must the time have been, that strata 10,000 feet thick may have been accumulated in other parts of the world during its lapse. Few geologists, however, appear to have realised this possibility, and we therefore find, when beds unmistakably of this middle age are under examination, that the question as to whether they are of Cretaceous or Eocene age is hotly disputed. We also usually find that when there is any internal evidence of a bed, especially if containing plant remains, being older than the known Eocenes, it is at once stated to be contemporary with one or other of our Cretaceous formations, even when a comparison of the fossils, especially of the plants, would point to the impossibility of such being the case. I will endeavour to make the magnitude of this gap apparent.

The Eocenes are composed, without exception, of the comparatively local deposits of shallow seas, estuaries, and rivers, even those most essentially marine in character containing evidence that land was not far distant. The Chalk which stratigraphically precedes them, contrasts with them very strongly, being

purely oceanic, deposited over a wide area, and containing no indication whatever of the proximity of land. Confining our remarks for the present to England, we see that the Eocenes, some 2,000 feet in thickness, are the results of a chain of perfectly natural and connected events which can be traced. They are essentially detrital deposits, while the Chalk is oceanic. But although we can trace the deposition of the Eocene through every stage, as if it were a written book, when we attempt to connect its history with the deposition of the Chalk, we find the records are missing. How the Chalk area became converted from ocean to land, and for how long a time it had been land before the deposition of the Eocenes commenced, are questions which can only be solved, if solved at all, by a study of the rocks of other countries. In France, an older group of Eocenes exists than we have here; but even this is, apparently, quite as remotely separated from the Chalk as our Eocenes. The break is so absolute and complete, indeed, that the Cretaceous period again seems to us as distinctly separate from the Eocene as it was thought to be by the earlier geologists.

We have every reason to believe that the Chalk, being an ocean deposit, must have formerly covered wide areas, and that the existing masses, although still extensive, are but mere fragments which have escaped denudation. It is not surprising to find, therefore, that besides those portions of Great Britain and Ireland which, from its actual presence, were obviously covered by a continuous Chalk formation, its former extension over the whole of Wales, Scotland, great part of Ireland, and the Scilly Isles, has been traced. We may thus safely infer that it stretched, at least, continuously over Great Britain and far over Europe and the adjacent seas. But we scarcely know at all what were the limits on the present land surface even of the ocean which deposited it: for although there are Cretaceous deposits in Europe thought to indicate proximity to a shore-line, it is not ascertained whether these are truly contemporaneous with the Chalk of England, or whether they are the deposits of that later period when the ocean began to recede, prior to the elevation of part of its bed into præ-Eocene land.

The denudation of the Chalk, which must have been on a most colossal scale, had doubtless proceeded for ages before the deposition of the Eocenes commenced, since even their lowest beds consist of extensive tracts of flint ground into sand and pebbles. It has continued ever since, to how great an extent we learn but imperfectly, by the enormous beds of gravel and sand which form, to a large extent, the Eocenes, Pliocenes, and Pleistocenes, and by the shingle and sand banks of our present littoral.

But, in addition to this evidence, we have other and stronger

reasons to infer that the lapse of time was of vast duration, from the striking and complete changes which took place in the fauna and flora in the interval. From the commencement to the close of the Eocene period, as it is represented in England, the aggregate amount of progressive change is, notwithstanding repeatedly varied physical conditions, by contrast trifling, and it seems to have been effected so gradually that the types of life in the oldest and the newest Eocene are substantially the same.

The change in the types of the fauna throughout the Cretaceous period is also so small as to be almost entirely of the value now commonly recognised as specific and not generic. From the Neocomian to the Grey Chalk, wherever like conditions prevailed, the same groups of genera, especially if we take the Mollusca, are seen to reappear. The fauna and flora of each of these periods are, although much interrupted, continuous and similar, and notwithstanding that unrepresented intervals are indicated, there is no great break in geological time.

The Cretaceous and the Eocene faunas, on the contrary, seem, when compared together, to have nothing in common, and so complete a change had taken place in them, that even the gap between the Jurassic and Cretaceous periods, judged by their organic remains, was small compared to this. How or when the Cretaceous fauna disappeared, we cannot trace in this area; we only know that it existed in seas which deposited the Chalk, and had ceased to exist here when the Eocene time arrived. Yet we know that the extinction must have been a natural and gradual one, since we see in America, and also in many other countries, that chambered Cephalopoda and *Inocerami*, for example, of late Cretaceous types lived long after the time in which we have any record of them in this country, mingled with mollusca, whose general features are strikingly similar to those of our Eocene.

The inference from all this is necessarily, that great as the lapse of time must have been during the accumulation of Cretaceous or Eocene, immeasurably greater was the period, of which we have no record here, which elapsed between the close of the one series and the commencement of the other. We might reasonably, therefore, expect to find in other parts of the world, deposits thousands of feet in thickness, belonging to the intermediate or Cretaceo-tertiary age, as Hector has named it, without, perhaps, even then having the gap entirely filled up. We believe that ocean spread widely over Western Europe, at least, in the Chalk portion of Cretaceous times; and it would therefore be almost impossible that any but the merest traces of the land vegetation of that period could be met with in our own or even in any adjacent country.

We know, it is true, but little of the earlier Cretaceous floras, but what we do know of that of the Neocomian shows it to be closely similar to the Wealden flora, and this has most affinity with the Jurassic. In the Gault I have collected, with the assistance of John Griffiths, at Folkestone, for 20 years, and five new species of cones have been described by Mr. Carruthers from the collection I have made alone. Notwithstanding that branches of conifers with leaves attached are by no means rare, that a variety of cones have been found, and that wood and resin is abundant, no trace whatever of a dicotyledon has been met with. In a Gault deposit of Hainault eight distinct cones and much wood, both of conifers and cycads, were met with, similarly without the presence of any dicotyledon.* Neither has any trace of them been found in the Green-sands or the Chalk. Notwithstanding this, it has been said that the Gault contains the dawn of the present flora; but we see at Folkestone that the Gault fauna melts most gradually into that of the Grey Chalk overlying it; and therefore if any inference may be drawn, it would be, that as we see even a less amount of change in the flora than in the fauna from Jurassic to Cretaceous, and in other times, whenever it has been possible to observe it, there is no reason to suppose it changed more rapidly than the fauna between Gault and Chalk. Without, I hope, attaching undue importance to negative evidence, it must be allowed some weight in the absence of any other kind, and in this instance, it is against any flora which contains dicotyledons being as old as our Chalk, and far more, the Gault.

Certain floras, described as Cretaceous, have been met with in Austria, Saxony, Bohemia, Silesia, Moravia, some of which have been stated to be of Lower Chalk-age; and a considerable flora, reputed to be contemporary with our Upper Chalk, has been collected at Aix-la-Chapelle. The age of these deposits however is of the greatest uncertainty, and has been recognised upon mere opinions, which have differed so much at times that the same beds have been assigned to very different divisions of the Cretaceous, and even to other and younger series. The lithological characters and the nature of the floras render it probable that the Aix-la-Chapelle flora especially may be Eocene, and the others rather older, but of a period long subsequent to the Cretaceous formation in England. The diversified characters and frequently Eocene aspect of these supposed newer Cretaceous floras, wherever they are found in Europe are so opposed to the intimate interconnection existing between those of the Eocene and Miocene of the same area, as to furnish additional proof that their ages must be very various, and

* M. Coéman's "Flore fossile de Hainaut."

cannot in all cases have been rightly determined. The very reasons which render it unlikely that any floras of Chalk age or remotely separated from the Eocene, should exist in our area, make it the more probable that they are to be met with in distant localities. The Chalk ocean did not extend over all the globe, and some floras should be found, as it is unlikely that all vestiges of land deposits of a period presumably of far longer duration than the whole Eocene time should have been swept from every part of it. And we find this to be the fact, for within the Arctic Circle have been found the remains of an evidently Cretaceous, and another which I take to be a præ-Eocene flora. In New Zealand we find a Cretaceo-Eocene series of great thickness, near the base of which occurs "an abundance of fossil leaves of dicotyledonous trees, zamias and palms."* In Vancouver's Land there are 4,000 feet of strata overlying the Nandimo coal beds, containing ammonites, baculites, and *Inocerami* from top to bottom: yet these are mingled with Eocene and even Miocene forms of mollusca, and are associated with oak and poplar leaves.† In India, an otherwise Cretaceous fauna includes gasteropoda with a decidedly Tertiary facies, and this appears to be the case in still other countries.

In America, great consecutive series of deposits, resting on old rocks, and extending in time from some post-Cretaceous date to the Pliocene, contain extensive fossil floras. A great part of these have been described by American writers as Cretaceous, from the intercalation of marine beds with some animal remains, characteristic in Europe of the Cretaceous period. But it seems certain, from the mixture of characteristic Eocene types, that the existence of these forms was continued for a prolonged period in America after it had ceased here. We also see that a land fauna including Cretaceous types, and a peculiar, simple, and probably indigenous flora, since it has not been met with elsewhere, lived there for a long time, isolated from the more advanced types which flourished in Europe. These appear to have been almost suddenly replaced by a fauna and flora of newer and more tropical character, and, in many respects, allied to our Eocene, when land communication existed between the two hemispheres in Eocene times. The whole evidence, when carefully weighed, tends to prove that all the plant-bearing beds of America, containing dicotyledons, which have been described as Cretaceous, are of Cretaceo-Eocene age. They thus become of great interest, as partially, at least, filling up the great gap existing in Europe.

* Hector, "New Zealand Institute Trans." Vol. iv., 1871, p. 345.
† Geol. Surv. Canada, 1873–74, p. 260.

It appears, therefore, although only upon strong negative evidence, no other being possible, that dicotyledons did not exist in floras so remote in age as the Gault. There is even no direct evidence that they existed during the Chalk, for no dicotyledons are yet known from it or beds *ascertained* to be contemporary with it. The date of their first appearance is still uncertain; but in Greenland, a leaf of simple form, ascribed to a poplar, is seen with what appears to be evidently a true Cretaceous flora. Of the many other so-called Cretaceous dicotyledonous floras, whilst some, as that of Aix-la-Chapelle, are, if botanical evidence can yet be said to be of any value, probably Eocene; others appear, at most, to be præ-Eocene. Between the Eocene and Chalk there is an immense gap, represented elsewhere by important formations, and to this period the older dicotyledonous floras may, for the present, be safely referred. The true Cretaceous floras are still almost completely disconnected from those which are post-Cretaceous; but we know so little of the relative ages of the latter, that it is safer, at present, in speculations, to leave out of consideration all groups of plants which are from beds whose age is not stratigraphically determined. It is most important that the existence of this intermediate zone should be clearly recognised, and the name made use of by Hector, "*Cretaceo-Eocene*," might well be adopted. The term "Palæocene," used by Schimper, has been applied to lower or even middle Eocene floras, and its continuance would therefore involve much confusion. While a special designation is a necessity for infra-Eocene deposits, the term Oligocene is, upon plant evidence, wholly unnecessary. From Eocene to Miocene there is no break whatever, and an Oligocene formation has to be created, so far as plants are concerned, from even distinctly middle Eocene formations.

REVIEWS.

ANIMAL CHEMISTRY.*

IT is with pleasure that we welcome the present work, which seems well designed to meet the want of a good modern work on animal chemistry, and well fitted to form a companion volume to Miller's "Elements of Chemistry." The author has divided his work into five parts, as follows:—I. General; II. Organs, fluids, and processes concerned in digestion, &c.; III. Nutrition, or "work and waste"; IV. Other organs, tissues, and fluids of the body; V. Chemical and philosophical subjects.

Under the first head Mr. Kingzett gives a brief sketch of the early history of the subject, lightly touches on the connection between vital and chemical phenomena, and concludes with a short statement of his views on the relations between modern chemistry and physiology and pathology. In the second part (pages 47–123) we find an account of the chemistry of the saliva, gastric juice, bile, liver, &c., giving a brief account of the principal normal and abnormal constituents. In the third part (pages 123–263) under, the general head of nutrition, a fuller account is given of the chemistry of the chyle, lymph, blood, urine, sweat, &c., of the process of alimentation and respiration, and of the connection of animal heat, vital force, and muscular oxidation, together with a brief sketch of the chemical dynamics of the body. Part IV. (pages 263–359) is devoted principally to the chemistry of the constituents of the brain; but concludes with a brief notice of the constitution of the bones, teeth, milk, pus, &c. Finally, the last part, V., may be divided into two portions: the first (pages 359–416) deals at some length with the chemistry of the albuminoids, and ends with an outline sketch of the carbo-hydrates and fats; the second portion is miscellaneous, and touches on the diverse subjects of fermentation, putrefaction, germ-theory of disease, antiseptics, "sanitas," physiological action of different chemical substances on character, as examplified by the genius and the fool, on the teaching of animal chemistry, and on different researches which ought to be undertaken. The work ends with a good index and list of authorities.

We are decidedly of the opinion that the present work will form an important contribution towards the advancement of our knowledge of

* "Animal Chemistry, or the relations of Chemistry to Physiology and Pathology." A manual for medical men and scientific chemists. By C. T. Kingzett, F.C.S. 8vo. London: Longmans, Green & Co., 1878.

animal chemistry, and that it will prove a valuable addition to the literature of this branch of science. It is true that we cannot agree with all the conclusions arrived at in this work, and in instances we entirely disagree with the author's criticisms on the researches of other workers in the same field, but this is no more than might be expected in the case of an author with the decided and original views of Mr. Kingzett. The author states his ideas with clearness and force, and they are such as will well repay careful examination and consideration. In several instances he has succeeded in throwing much light on what previously were very doubtful questions, and thus earns the gratitude of those working on the subject. In several respects, indeed, we could have wished that the work had been rendered more complete. In more than one instance we have been disappointed in finding that important subjects had been merely glanced at, or were passed over with a bare reference when the work might have very well embodied some of the information now scattered about in isolated researches. In this respect the present work is not likely to take the place of a standard manual, which ought to contain a careful synopsis of all that is known on the subject. To a certain extent Mr. Kingzett's work possesses more of the character of an elaborate essay than of a treatise, both in its style and in its objects. At times more attention is devoted to criticisms, the opinions of different investigators, than to summarising the facts resulting from their investigations; although to us it would seem that these last were essential to the completeness of the volume.

The work presupposes a certain amount of chemical knowledge on the part of the reader, although no more than might reasonably be expected. Any additional information which may be required for special sections will be found supplied in the work. Mr. Kingzett rather discountenances the recent developments of theoretical organic chemistry. He has not introduced them, therefore, into the present work, which thereby gains in simplicity, if it loses somewhat in power. It is a work which we have no hesitation in recommending to all those who may require a knowledge of the subject of animal chemistry. To medical men we feel sure it will prove of great service; and to young scientific chemists it will suggest a field for invaluable researches.

PLEASANT WAYS IN SCIENCE.*

MR. PROCTOR has here collected eighteen essays, taken chiefly from the "Contemporary Review," the "Gentleman's Magazine," the "Cornhill Magazine," "Belgravia," and "Chambers' Journal." One is the substance of a lecture delivered at the Royal Institution, in May 1870.

The subject of the first is the Sun; of the second "drifting" light; of the third "star drift." The rest seem miscellaneous, and contain Mallet's "Theory of Volcanoes," "Towards the North Pole," a narrative of the Arctic Expedition of 1876, and an account of the tremendous wave which, in 1876, swept

* "Pleasant Ways in Science." By Richard A. Proctor. Sm. 8vo., London: Chatto & Windus, 1879.

the Pacific Ocean from Peru northwards, and which is shown to be due to an upheaval of the ocean bed. Then we have our old friends the kraken and sea-serpent: followed by some "marvels in telegraphy," and the phonograph. The gorilla, food, ozone, dew; the levelling power of rain, and ancient Babylonian astronomy, complete the list.

The book is essentially light and readable, suited to the "many who wish to learn about scientific discoveries without special labour, for which some have perhaps little taste, and many scant leisure."

Works of this kind are especially valuable for filling the smaller gaps in busy men's time to some profit, and without strong mental effort. A detached essay can be read, when a treatise would be neglected. Mr. Proctor's lucid style of writing materially aids in the mental assimilation of his topics. No doubt small inaccuracies may be found here and there; but the book hardly deserves the fastidious and somewhat pettish tone of general condemnation with which, under well-known initials, it has elsewhere been received.

W. H. STONE.

THE EUCALYPTUS.*

ALIKE the scientific and unscientific reader may profit by a perusal of this excellent manual of eucalyptus-planting. Its author, from his position as Agricultural Inspector to the Government of Algeria, writes with authority, and adds to his own valuable experience a large number of facts bearing upon this most important and interesting question. The *Eucalyptus globulus* (or Australian blue gum tree) is not only a fast-growing and ornamental garden tree; it is not only possessed of anti-febrile qualities to a remarkable degree; but it is moreover very productive from an economic and commercial point of view, affording a great variety of chemical and medicinal products, besides timber of excellent quality and astonishingly rapid growth. The plan of M. Certeux's little work is judiciously adapted to the wants of his readers. There is a general catalogue of *Eucalypti* to begin with; and following this is a classification of those species with which growers are most familiar, each being considered from various points of view. Thus we have only to turn to the index to find out which especial tree thrives in plains, marshlands, or sandy soil; which is richest in essential oils and tannin; which is the most effective in sanifying unwholesome districts; and which most speedily yields grateful shadow. We have also abundant information upon the various methods of planting and cultivating the tree, and the cost, as illustrated by the largest and most important experiments that have yet been tried, namely, those in Algeria. Lastly, we have a list of the multifarious, economic, pharmaceutical, and artistic preparations from *Eucalypti*, with many other details that the least scientific reader must find both interesting and instructive.

When we consider that M. Certeux's classified catalogue embraces 216 species or varieties, we shall see the difficulty of the task he has performed

* "Guide du Planteur d'Eucalyptus." Par A. Certeux. Paris: Challamel aîné.

so conscientiously and evidently *con amore*; the subject exercising an extraordinary fascination upon all who take it up.

To show how much attention has been given to the eucalyptus in its adopted home of Algeria, we will only mention one fact. In 1876 there were no less than 119 species growing in the experimental plantations of El-Alià belonging to one chemist alone, M. Cordès. This, probably the largest collection in the world, is due entirely to private enterprise, and too much praise cannot be accorded to such services rendered to science in the teeth of all kinds of difficulties and disadvantages. All who have made themselves familiar with French colonization in Algeria must admire the public spirit displayed within the last twenty years on behalf of the *réboisement* or replanting of the country, a measure so necessary alike on sanitary and economic grounds. Already the effects of this movement are being felt in many districts, and M. Certeux points out other benefits likely to accrue from the young eucalyptus forests.

Take the prevalence of ophthalmia in treeless countries, for instance. We all know that the glitter and blaze of the Egyptian or Algerian atmosphere account for the painful maladies of the eyes and blindness so common in these countries. Plant the fast-growing, umbrageous eucalyptus trees, and the causes of the evil would disappear. Again, we have here many novel and interesting facts for the bee-keeper. The eucalyptus, in consequence of its abundant flowers, attracts the bees, and wherever it has been planted the bee has followed it; the species best adapted for apiculture being the *E. globulus*, *E. gigantea*, *E. odorata*, *E. roseata*, *E. amygdalina*, and *E. siderostylus*.

Many valuable preparations have already been added to the pharmacopœia by the essential oils, bark, and leaves of this tree, and there can be no doubt that others await discovery. M. Certeux's manual will prove equally useful to the scientific student therefore, since he gives not only a list of the different medicines and medicaments, but an analysis of each. He also gives extracts from the treatises of M. Cloëz and other analytical chemists who have made the eucalyptus an especial study. On the whole, this is a little work botanists, agriculturists, and the lovers of natural science generally will do well to consult, and it has the advantage of containing a vast amount of information in a small compass.

THE GEOLOGY OF IRELAND.*

WITH Prof. Ramsey's "Physical Geography and Geology of Great Britain," Mr. Horace Woodward's "Geology of England and Wales" and Prof. Hull's "Physical Geology and Geography of Ireland," it might be thought that the ordinary reader had an abundant supply of information upon the structure of these islands, but an examination of Mr. G. H. Kinahan's "Manual of the Geology of Ireland" will show that upon this part of the kingdom at any rate there was still a good deal to be said. Mr. Kinahan in his treat-

* "Manual of the Geology of Ireland." By G. Henry Kinahan. 8vo. London: C. Kegan Paul & Co., 1878.

ment of the subject goes into more local detail than Prof. Hull, his work in this respect exhibiting some resemblance to the second of those cited above, and by this means he succeeds in producing a very vivid picture of the geological structure of Ireland. In some points of stratigraphical geology he differs in opinion from the survey of which he is a member—the Lower Silurian rocks of the survey are for him Cambro-Silurians—the Old Red Sandstone of Ireland, at any rate, follows the Yellow Sandstone into the Carboniferous series; and his treatment of the unmistakable members of the latter differs somewhat from that which must be regarded as orthodox from a survey point of view. The author does not, any more than Prof. Hull, recognise the presence of Pre-Cambrian rocks in Ireland, so that we must wait until Mr. Hicks can make an exploration of the Sister Isle, before we can hope to hear of the existence of Irish Pebidians, Dimetians, and Arvonians.

In his first section Mr. Kinahan treats of the Sedimentary formations; his second is devoted to the metamorphic and eruptive rocks, upon the nature and production of which, as is pretty well known, he holds certain opinions of his own. His views with regard to metamorphism are stated as follows: "Metamorphic and eruptive rocks. . . are intimately connected, all being indirectly due to Metamorphic Action. . . . One kind of metamorphism is *Regional*, or extends over large areas. The rocks affected by it seem to have been under the influence of intensely heated water or steam which, as it were, stewed them, from which the action may be called *Metapepsis*. Another kind is merely *Local*, its effects being only found immediately adjoining intruded masses of rocks, or in the vicinity of vents where gases, steam, or other products of vulcanicity found egress. When typical, this kind of metamorphism produces in the rocks an appearance as if they were baked, from which it may be called *Paroptesis*. It is not, however, always typical, as many of the altered rocks must have contained moisture, which, when heated into steam, would give results more or less similar to Metapepsis, except that the action would be confined to limited areas. . . . There is a third class of Metamorphism which is also local. It is due to the introduction and action of chemical substances from without; it has been called *Methylosis*. . . . Metapeptic action is the metamorphism that is most interesting to the geologist, as it is by the extreme action of it that eruptive rocks have been formed." From this point of view Mr. Kinahan forms a classification of the Eruptive and Metamorphic rocks, in accordance with which he treats those which occur in Ireland in the same local detail as the sedimentary deposits.

A third section treats of the superficial accumulations and includes not only a discussion of the Drift and Glaciation of Ireland (the details of the latter do not appear to be quite so well settled in Mr. Kinahan's mind as in those of some other observers), but also an account of ancient sea-margins, great deposits, and the pre-historic remains of man, upon which Mr. Kinahan has naturally a good deal to say. We have here also a chapter on the Post-Pliocene Mammalia.

Section IV. treats of the physical features of the country; and Section V. of its economical products in the shape of minerals, building and other stones, and mineral manures. This last section is of much practical importance, and its

value is increased by a list of mineral localities arranged in counties, with indications of the particular form of mineral wealth to be obtained in each of them. This section closes with a short article on the water supply. In an appendix we have a glossary of Geological and Celtic terms. The book is illustrated with a good many woodcuts of sections and scenery, most of which are very good, and with some plates of fossils, the figures in which, although rather rough, are characteristic. There is also a nicely coloured geological map of Ireland.

In this little book Mr. Kinahan has certainly succeeded in producing one of the most original and thoroughgoing treatises on local geology that it has even been our good fortune to peruse, and geologists are deeply indebted to him for giving them so admirable a guide to the geology of his native country. It is rather sad to see that the book is dedicated to Sir Richard Griffith, whose death must have taken place almost at the time of its publication.

ETNA.*

ALTHOUGH the largest volcano of Europe, and the one which, according to history and tradition, has been the longest in action, Etna seems to have achieved but scanty fame in this country, and the surprise which the author of the little volume now before us experienced on finding that there was no special work upon this mountain in the English language was certainly justified. Its younger sister on the continent of Italy is much better off in this respect, owing, no doubt, in part to its proximity to Naples and to the comparative facility with which its summit can be reached: in part also to the celebrity attaching to it as at once the destroyer and preserver of the two cities of Herculaneum and Pompeii. The fabled prison of the rebellious giants and forge of Vulcan has, however, received more justice at the hands of foreign writers, among whom Carlo Gemellaro and Sartorius von Waltershausen stand pre-eminent, as the authors of special "Ætnographies," whilst our own countryman the late Sir Charles Lyell has contributed in no small degree to the explanation of the phenomena presented by the mountain. In fact, as Mr. Rodwell tells us, "later writers usually quote Von Waltershausen and Lyell, and do not add much original matter;" and, considering the quality of the work done by those distinguished geologists, this may be taken rather as a compliment to the judgment of the later writers, of whom our present author is one. So far as we can see Mr. Rodwell in his little volume (which is an expansion of his article "Etna," in the "Encyclopædia Britannica") adds little to the stock of knowledge previously possessed by geologists as to the structure of the mountain, although it would be unfair to stigmatise his work as a mere compilation, seeing that while he cannot claim that it is the product of original research, the author nevertheless in bringing it together had the advantage of a personal acquaintance with the locality under consideration. Mr. Rodwell has in point of fact produced an excellent and readable popular account

* "Etna: a History of the Mountain and of its Eruptions." By G. F. Rodwell. 8vo. London: C. Kegan Paul & Co., 1878.

of the great Sicilian volcano. He opens with a history of the mountain, or rather of the knowledge of the mountain, then describes its physical features in detail, including in this category the peculiarities of distribution of animal and vegetable life upon its surface; gives an account of his experience of an ascent to the summit, which includes many useful hints for those who may desire to follow in his footsteps; and finally notices the various towns situated on the slopes of Etna itself, which are interesting in many respects, and appear to be in a flourishing and increasing condition. The fifth chapter contains a chronological account of the recorded eruptions of Etna, of which the author notes seventy-eight, the earliest in the time of Pythagoras, B.C. 525, the latest in 1874. The earlier traditions, which would carry back the activity of the mountain as far as the year 1226 B.C., are mentioned by Mr. Rodwell, but not regarded as sufficiently authentic to be relied on. In most cases, but especially with reference to the more violent eruptions, the phenomena manifested are briefly described. In the sixth chapter the author descants, briefly, as may be supposed, upon the geology and mineralogy of the great volcano, and here we find references to recent investigations by Professor Silvestri, and to the results of original researches, supplemented by an appendix by Mr. Frank Rutley on the microscopic characters of the lavas of B.C. 396 and A.D. 1535, 1603, and 1689. The constituents of these lavas are "plagioclase, augite, olivine, magnetite, and, in some cases, sanidine—possibly titaniferous iron—and in some, if not in all, a slight residuum of glass;" and Mr. Rutley remarks upon the close similarity of structure presented by these lavas, the first and last of which are separated by an interval of more than 2,000 years. Drawings showing the microscopic structure of these two lavas are given. The other portions of the book are fully illustrated with drawings and maps, some of the latter coloured.

SILURIAN FOSSILS OF GIRVAN.*

THROUGHOUT the South of Scotland, wherever fossiliferous rocks occur, they are so twisted and twirled about that the attempt to arrive at any definite conclusion as to their succession is a matter of no small difficulty. One of the best examples of this is to be found in Mr. Lapworth's recent paper on the rocks of the Moffat district, the extreme complication of which could only be elucidated by years of work upon scattered exposures of beds containing graptolites. Still further west, in the district of Girvan, in Ayrshire, the Silurian rocks are almost equally confusing. Great masses of eruptive rocks have been pushed up through the sedimentary and metamorphic beds, and the latter have, in consequence, been thrown into several folds within the distance of a few miles. By the action of faults and of rivers cutting down into these deposits the fossiliferous Silurian rocks are exposed here and there; but the exposures are so unconnected that the correlation of the

* "A Monograph of the Silurian Fossils of the Girvan District, in Ayrshire." By H. Alleyne Nicholson, M.D., &c., and Robert Etheridge, Jun., Fasciculus I. 8vo. London and Edinburgh: Blackwood & Sons, 1878.

various deposits can only be effected by a thorough investigation of their fossil contents.

This is the task which Messrs. Nicholson and Etheridge have set themselves to fulfil, with the aid of a grant from the Royal Society. A considerable number of fossils had already been described from the Girvan deposits; but, as a matter of course, in many cases the descriptions were unaccompanied by those precise stratigraphical details which alone could render them available for the interpretation of the beds: and the authors were under the greatest obligations to Mrs. Gray, of Edinburgh, whose collections, amassed with the greatest care, were placed freely at their disposal. Accordingly their monograph of the fossils, of which the first fasciculus is now before us, is stated on its titlepage to bear special reference to the fossils contained in the "Gray collection."

In this first fasciculus the authors describe the Rhizopoda, corals, and trilobites which have been collected from the Silurians of Girvan, and which, especially in the first two groups, include many exceedingly interesting forms, a great number of them representing species and even genera previously unrecognised. The study of the corals leads the authors to certain general views as to the age of the deposits from which they are derived, and they distinguish the following local divisions:—

1. The Craighead limestone, which contains a peculiar set of corals, indicating Lower Silurian age, and having an American facies, leading the authors to regard it as corresponding to the upper part of the Trenton Limestone, or the base of the Cincinnati and Hudson River formations of North America.

2. The Mulloch Hill beds, containing *Heliolites interstinctus* and other fossils, indicating an age equivalent to that of the Upper Llandovery.

3. The Penkill beds, with the above *Heliolites*, *Halysites catenularius* and a species of *Calostylis*, indicating a position in the lower parts of the Upper Silurian series (Wenlock?).

4. The Shalloch Mill beds, containing *Favosites gothlandicus* and *Alveolites Labechei*, unmistakably indicating Upper Silurian age.

5. The Balcletchie beds, coarse, fossiliferous volcanic ashes, with very few corals, which the authors suppose to be nearly of the same age as the first mentioned series.

It will be seen that although the materials for forming a notion of the stratigraphical relationship of these deposits are still scanty, certain definite points are already laid down, and in all probability the authors will be able, before concluding their labours, to arrive at satisfactory results. Under any circumstances, however, even if the extant material be insufficient for this purpose, they will leave to future investigators of this interesting district a great mass of most valuable material admirably worked up. It is, in fact, impossible to speak too highly of the conscientious and careful manner in which Messrs. Nicholson and Etheridge have performed their self-imposed task; but their style of work is so well known to all palæontologists, that we may spare ourselves the trouble of seeking for complimentary phrases in which to express our appreciation of their present effort. The work is illustrated with nine plates of fossils, lithographed by Mr. Berjeau, partly from nature, partly from the drawings of Dr. Nicholson, and of these we

can only say that they are equally deserving of praise with the literary part of the book. As a whole this fasciculus is a piece of palæontographical work of the very highest character, and we trust that the authors may be encouraged, by the reception it meets with from their *confrères* and the public, to complete it in the same style.

WEST YORKSHIRE.*

FOR the geologist the great county of Yorkshire must be looked upon as classical ground. In 1829 John Phillips, in the first part of his "Illustrations of the Geology of Yorkshire," which treated of the Yorkshire coast, gave the earliest practical illustration on an extended scale of the application of the principle of determining strata by their organic remains, which had just been promulgated by his uncle, William Smith; and the county has ever since been noted for the great amount of attention which has been devoted to its exceedingly interesting geological structure. In 1836 Phillips completed his work on the geology of his adopted county by the publication of a second and much larger part, in which those portions of Yorkshire lying to the west of the great vale of York were most elaborately described; and at that early date no other county in England could boast of having its geology so thoroughly worked out.

This pre-eminence has doubtless been considerably diminished in the lapse of more than forty years, partly by the progress of individual research, and partly by the action of the Geological Survey in other counties; and unquestionably by both these agencies some modifications have been introduced in the geological idea of Yorkshire as originally drawn by Phillips. That geologist had, indeed, nearly prepared for publication a new edition of his first part (subsequently brought out under the care of Mr. Etheridge), embodying the results of investigations which had been made by others upon the eastern part of Yorkshire. The work of Messrs. Blake and Tate upon the Yorkshire Lias is one of great importance; and the number of memoirs published in various periodicals upon the secondary strata of the county is very great.

By its geological construction Yorkshire is naturally divided into two very distinct parts. Right down the middle of the county runs the wide vale of York, with its Triassic beds, separating the secondary rocks of the North and East Ridings from the palæozoic formations of the west of Yorkshire, as effectually as if the former constituted an island cut off by an arm of the sea. Since the completion of Phillips' "Illustrations" the western division has received no small share of attention from geologists; in fact, the authors of the book before us give a list of nearly 500 separate works and scattered memoirs relating to the geology and physical geography of the region of which they treat, and which includes not only some of the most interesting scenery in England, but also extensive deposits of coal, and many great

* "West Yorkshire: an Account of its Geology, Physical Geography, Climatology, and Botany." By James W. Davis and F. Arnold Lees. 8vo. London: L. Reeve & Co., 1878.

industrial towns which have sprung up in consequence of the vicinity of abundant fuel. We must remark, however, that Messrs. Davis and Lees confine their attention in this book exclusively to the West Riding of Yorkshire, leaving out of consideration the western portion of the North Riding, which nevertheless forms a continuous whole with the district investigated by them. This seems to be a pity; but perhaps the authors might urge in defence of the course they have adopted that their western boundary is as arbitrary as their northern one, and that they might with equal justice be called upon to carry their researches into the neighbouring counties of Lancashire and Westmoreland. So let us be thankful for what we have got and are promised.

It appears from the authors' statements that they had hoped to embrace in a single volume all that they have to say on the geology, physical geography, and botany of the West Riding of Yorkshire. In this expectation they have been disappointed, and this first instalment—which, we presume, may be regarded as constituting half the entire work—includes the geology of the district worked out by Mr. J. W. Davis, and the physical geography and botanical topography in accordance with the various drainage areas, by the combined labours of both authors.

As the eastern boundary of the Riding is formed by the Ouse and Humber it includes a considerable portion of the Triassic formation of the great central valley, but the great mass of the district is composed, as above stated, of Palæozoic rocks. In the north-west corner the Silurian rocks, which form the chief part of the adjoining county of Westmoreland, occupy a small space, and are exposed in considerable thickness in various sections; along the eastern border of the Palæozoic area stretches a great band of Permian rocks; while the remaining space is occupied by different members of the great Carboniferous group, here very fully represented. All these formations, with their subdivisions, as well as the Trias of the vale of York so far as it falls within the Riding, and the post-Tertiary drifts and other more modern deposits which cover so much of the latter and occupy parts of the valleys among the older rocks, are described by Mr. Davis in accordance with the most recent investigations, checked and corrected by his own researches especially among the coal-measures. His description of the geological structure of West Yorkshire is illustrated with an excellent coloured geological map and twenty-one plates, sixteen of which represent actual sections in black and white, while the remainder contain coloured diagrammatic sections of different parts of the area. Mr. Davis thus furnishes the student with an excellent *résumé* of West Yorkshire geology, particularly well adapted to serve as a guide in its practical investigation, especially as his lists of the fossils obtained from the different formations are very full and complete.

In the second part, which is the joint production of both authors, the surface conformation of the district is treated of, with special reference to the distribution of its native plants, which are here noticed in accordance with the river drainage-basins in which they occur. This section of the work is illustrated with a map of the Riding, in which the different drainage areas are distinguished by colours. The richness of the flora appears from the fact that 1,180 species of flowering plants, ferns, and fern-allies have been

found growing within the district, of which 904 are regarded by the authors as truly indigenous; whilst 319 mosses, 232 lichens, 75 liverworts, and 388 fungi have also been recorded as natives. To the student of botanical topography this work of Messrs. Davis and Lees, with its descriptions of physical conditions and lists of peculiar plants, cannot fail to be of interest; while the latter will be most welcome to collecting botanists, whose numbers are by no means inconsiderable among the handicraftsmen of the West Riding. The second volume, which will treat of the climatology and flora of the Riding and their connection, will add very considerably to the value of this treatise on its botanical topography.

THE ART OF SCIENTIFIC DISCOVERY.*

THE necessity for works of a constructive and methodic character, in an age occupied with the incessant gathering of facts, has already been adverted to in these pages. What Mr. Skertchley proposed to do for cosmogony Mr. Gore attempts in the cause of human thought. He proposes "to describe the nature of original scientific research, the chief personal conditions of success in its pursuit, the general methods by which discoveries are made in physics and chemistry, and the causes of failure; and thus to elucidate as far as possible the special mental conditions and processes by means of which the mind of man ascends from the known to the unknown in matters of science."

As a known expert in physical research he has an undoubted right to contribute to the long list of such works which have sprung from the philosophic mind in various ages. First among these comes the "Organon" of Aristotle, a treatise to which its shrewd and practical author gave the familiar name, inasmuch as it was to be a "tool" or "implement" in the hands of mental workers, by means of which they should dig out truth. It once and for all showed the capabilities of the deductive method of logic in averting error. Many ages after arose a New Organon, a tool adapted to the changed aspect of men's minds, and the dawning of the inductive method, carried only of late to its highest development in the great work of Mill.

But perhaps the nearest kinsmen of a book like this are the "Regulæ Philosophandi" of Newton; near, because they too were concerned with physical inquiry; and nearer still because as rules they presupposed an art, and did not aim at the foundation of a new science.

There can be no doubt, as the writer says, that "an art of scientific discovery is much more possible now than it was in the time of Lord Bacon, and is fast becoming more so, and that the process of scientific discovery can even now be much more completely reduced to order and rule than is generally supposed." It depends on "a combination of experiment and logical inference," the latter of which has been "insufficiently studied, the success achieved having, therefore, been attributed too much to accident, to

* "The Art of Scientific Discovery, or the General Conditions and Methods of Research in Physics and Chemistry." By G. Gore, LL.D., F.R.S. Sm. 8vo, pp. 648. London: Longmans, Green & Co., 1878.

strong imagination, and to exceptional natural ability; too little to the less brilliant qualifications of steady thought, self-development, industry, and perseverance."

The book is in five parts, the first containing a general view of the subject; the second, general conditions of scientific research; the third, personal preparation for research; the fourth, actual working in the art; and the fifth, various special methods of discovery, classified, and illustrated by numerous examples.

It is impossible in a short notice to go through the mass of matter contained in over 600 pages; but attention may be drawn to the remarks in Part II. on "unexpected phenomena," on "unexpected or accidental discoveries," in which, quoting Whewell, the writer lays down the rule that "no scientific discovery can with any justice be considered due to accident. In whatever manner facts may be presented to the notice of a discoverer, they can never become the materials of exact knowledge, unless they find his mind already provided with precise and suitable conceptions by which they may be analysed and connected." Very much the same remark was quaintly made by Aristotle in the aphorism that "All knowledge comes out of things known before."

The whole third part is deserving of study by those in charge of promising and intelligent pupils. It will tend to lighten the heavy responsibility resting on them. The following passage deserves quotation: "To be born before the time is almost as unfortunate as to be behind it. All original scientific investigators must, however, be more or less in advance of their time, otherwise they cannot be original at all. A scientific investigator may be before his age in more ways than one. Thus he may imagine and publish advanced and true hypotheses, the complete proof of which cannot be discovered until a later period. This was the case with Avogadro, and his hypothesis that equal volumes of different gases contain equal numbers of molecules. It is probably the case with some existing eminent men and their hypotheses. Or he may, as Galileo did, and Bruno shortly before him, publish his views and the proofs of them at the same time. But in either of these cases, if the views he publishes or even appears to hold, conflict with, or only appear to conflict with, the current creeds and unproved dogmas of theological belief, his character is privately attacked, and the minds of female members of his family (who can rarely understand science, but are easily influenced by feeling and religious emotion) are perverted, and his home happiness injured. In other instances his means of living are diminished. It is worthy of notice that every great pioneer of science, including even Newton himself, has been and still is accused by the ignorant of holding false opinions and beliefs, even in cases where those beliefs have been proved to be true. Retreating dogmatism continually says to the scientific investigator, 'Thus far shalt thou go, but no farther,' but science keeps marching on."

Part IV. describes the selection of a subject of investigation, the mode of conducting it, the value of many and various experiments, and of close measurements, the classification and explanation of results.

The fifth part is more miscellaneous. Empirical methods of discovery, the extension of neglected or undeveloped parts of science, the use of new instru-

ments, the investigation of likely circumstances, the testing of hypotheses, methods by comparison of known truths, by calculation based on known truths, and many other topics, are in turn considered, always with clear perception and abundant apposite illustration We must, however, go back to the first few pages for a confession of faith which gives its savour to the whole work. It is there affirmed that "one of the most perfect ways in which we can show our obedience to the Creator and our feeling of thankfulness for the numberless blessings we enjoy, is to develop new truths, and thus to hand down a larger share of their good results to our successors. One of the greatest bequests man can make to his fellow-men is the discovery of a great general truth. Discoveries are living waters, fresh from the fountain of intelligence."

W. H. STONE.

THE STEAM ENGINE AND RAILWAYS.

WE have had many books, popular and technical, written on the steam engine; but hackneyed as the subject may appear, a perusal of Professor Thurston's little volume * just published will show that there is still plenty of life in it. In this excellent treatise, which forms a part of the "International Scientific Series," the author adopts a rational historical treatment of his subject. He commences with the period of speculation, extending from the earliest recognition of the motive power of steam by Hero and other Greek philosophers to the time when the Marquis of Worcester first succeeded in applying this power to the performance of actual work; and then describes the efforts made in this direction during what he calls "the first period of application." In this section of the subject we find the steam engine acting as a simple machine, with a single application to the business of pumping water, which it effected with more or less success. These rude inventions (among which we find engines worked by alcohol and gunpowder) performed a certain amount of work, and although their defects were serious, the efforts of mechanicians to improve them led to the employment of many useful contrivances. As Professor Thurston says: "The steam engine, as a simple machine, had been given as great a degree of perfection by the successive improvements of Worcester, Savery, and Desaguliers, as it was probably capable of attaining by any modification of its details," and "it now only remained for the engineer to combine known forms of mechanism in a practical machine, which should be capable of economizing and conveniently utilizing the power of steam through the application of now well-understood principles, and by the intelligent combination of physical phenomena already familiar to scientific investigators." In other words, the steam engine had to become "a train of mechanism," and it is to the history of its development in this form, commencing with the efforts of Newcomen in 1705, that the greater part of the present volume is devoted. The author traces most clearly and admirably

* "A History of the Growth of the Steam Engine." By Robert H. Thurston, A.M. Sm. 8vo. London: C. Kegan Paul & Co., 1878.

the progressive steps by which the gigantic power of steam has been made subservient to human needs, until at length its applications have become so general that we have ceased to marvel at what are really the most wonderful triumphs of mechanical skill. From the time when Watt virtually completed his improvements of the steam engine, about the year 1780, down to 1850, constitutes what Professor Thurston calls the "second period of application," during which the strength of the tamed giant was being utilised in the most various ways; and the history of this development of the application of steam to useful purposes, and especially in locomotion, both by land and water, is given in considerable detail. Then follows what is denominated "the period of refinement," extending from 1850 to the present day—a period during which constant modifications and mechanical improvements have been introduced into the steam engine to fit it for special purposes. The author concludes with two chapters on the philosophy of the steam engine, embracing the physical principles involved in its construction and working, which will be found of great interest and importance. The work is admirably illustrated throughout with woodcuts, and is undoubtedly the best general popular treatise on the subject that we possess.

Professor Thurston naturally devotes a considerable share of attention to the development of the railway system, which must be regarded as the most potent agent in that revolution that has taken place in the social condition of civilized nations. Thackeray considered that in this country, at any rate, society passed out of its old into its new development during the reign of George III.; but it has always seemed to us that the old-world conditions prevailed continuously, under gradual modification, of course, until a later date, and that the great revolution in all our habits and modes of thought may be held to date its origin from the introduction of the railway system and of ocean steamers, say with the inauguration of the Manchester and Liverpool line in 1830, less than fifty years ago. We know what has taken place since then, within the lifetime of a middle-aged man—how completely all the habits of people have changed—how enormously all the capitals of Europe and the great centres of industry have increased—how the electric telegraph, springing out of the needs of the railway system, has entirely changed the nature of all business transactions, and brought nearly the whole world close together—and how great a progress has been induced in a thousand other directions, which may be referred, indirectly perhaps, to the same influence.

Mr. Parsloe, while going to some extent over the same ground as Prof. Thurston in his account of the first steps in this gigantic innovation, may virtually be regarded as taking up the story where the Professor leaves it, in his little volume (just published) on "Our Railways." * After some interesting sketches illustrating the old and new systems of travelling, and the difficulties and opposition which the introduction of the latter met with, he proceeds to give a history of the development of the railway system in this country, the construction of railways, the mode in which the existing iron

* "Our Railways: Sketches Historical and Descriptive, with Practical Information as to Fares and Rates, &c., and a Chapter on Railway Reform." By Joseph Parsloe. Sm. 8vo. London: C. Kegan Paul & Co., 1878.

network has grown up, the use of signals, gauges, brakes, &c., and then describes the whole method of railway management, tickets, luggage, express trains, the official staff of a railway, the system of accounts, and management of the clearing-house. He discusses these and many other matters connected with railways and railway travelling, legislation, and reform, and altogether presents his readers with a mass of exceedingly interesting and practical information on the subject, which cannot but be useful in the present day, when, considering the mode in which the railway system has come to pervade our whole lives, it is of great importance that the public should have some idea of the working of this mighty agent of change. In the closing chapters of his valuable little book Mr. Parsloe briefly notices the development of railways on the continent of Europe and in North America.

THE TELEPHONE AND PHONOGRAPH.*

SO many novel applications of electrical science have lately been announced from the other side of the Atlantic, that the reader of such a journal as the *Scientific American*, unless indeed he happen to be a specialist, is likely enough to get bewildered by the multiplicity of inventions that are forced upon his attention. Mr. Prescott has therefore done well to collect into a single volume much that has been written on these subjects, especially on the various forms of telephone. The latest American improvements in telephony are here described, and amply illustrated. In writing on such subjects it is difficult to avoid discussing the delicate question of priority of invention, and this question is especially prominent in connection with the Bell telephone. The evidence here adduced tends to show that the familar form of instrument known as the "handle telephone," generally attributed to Prof. Bell, was really devised by Dr. Channing and Mr. Jones in Providence, Rhode Island. The lecture delivered by Prof. Bell to the Society of Telegraph Engineers in this country is reproduced *in extenso*, by Mr. Prescott, but not without notes which slightly affect some of the lecturer's statements by pointing out the part which Mr. Elisha Gray has played in the development of telephony.

Although the phonograph is an instrument which is not based on electrical principles, it is very properly placed by the side of the telephone, and described in detail by Mr. Prescott. We find no mention, however, of either the microphone or the megaphone. On the other hand, the electromotograph of Edison comes in for description; and an interesting chapter is devoted to the subject of Quadruplex telegraphy. Curiously enough, another section is given up to the description of electric call-bells; while the work concludes with a chapter on the electric light. So much, however, has lately been written on electric illumination that the chapter does but scant justice to the subject, and represents very imperfectly the present condition of the question. Nevertheless some attention is given to the pro-

* "The Speaking Telephone, Talking Phonograph, and other novelties." By George B. Prescott. 8vo. New York: D. Appleton and Co., 1878.

duction of light by the incandescence of platinum and of iridium; and if rumour be true-tongued it is an alloy of these metals which Edison employs. No mention, however, is made of Edison's light; nor could this be expected, as we presume the volume was printed before the scientific world had been startled by the mysterious paragraphs which have since been circulated on this subject.

While believing that Mr. Prescott's volume will be widely useful in offering a compact account of many recent electrical inventions, it should be mentioned that much of the book is made up of papers published elsewhere by Dolbear, Grey, Page, Du Moncel and other electricians. We should not object to this method of book-making if the reprints and quotations were always clearly indicated by inverted commas or other quotation-marks. Unfortunately, however, such indications are used but sparingly, and the reader is therefore often at a loss to know where the quotations end, and whether he is reading the editor's or somebody else's words. There is much convenience as well as honesty in the American editor's maxim—to render unto scissors the things that are scissors'.

DANGERS TO HEALTH.*

THIS is an excellent, albeit a very quaint book. It takes its origin in a lecture on Sanitation, delivered two years ago by Mr. Teale before the Leeds Philosophical and Literary Society. "The truth of the matter," says the writer, "is this, that having discovered and rectified, one by one, numerous defects of drainage in my own house, and in property under my charge, and having further traced illness among my patients to scandalous carelessness and gross dishonesty in drain work, I became indignantly alive to the fact that very few houses are safe to live in. Probably no work done throughout the kingdom is so badly done as work in houses, drains, and pipes, which is out of sight."

Now the quaintness and at the same time the force of the book is the way its author sets about remedying an acknowledged defect in our social administration. He does not attempt a treatise which would be read by few and understood by fewer. But he takes every form of defect, whether arising from ignorance or from dishonesty, and he chalks it up on the wall as a terror to evildoers. "The design," he says, "I have set before myself is this, to represent pictorially every important fault to which domestic sanitary arrangements are liable." The fifty-four plates thus form a sort of *Danse Macabre*; a half-humorous series, at which one first smiles, and then shudders. Each plate is the body of an occupied house skilfully dissected. The baby is in its cot, the maid is in the dairy, the kettle is boiling on the kitchen fire, the invalid in her bed, the meat is in the larder, the cotter is smoking at his door, the women are gossiping around the common pump. But the picture goes below the surface; the various faulty drains, and inlets

* "Dangers to Health. A pictorial guide to domestic sanitary defects. 55 Plates with descriptions by T. Pridgin Teale, M.A., Surgeon to the General Infirmary, Leeds. 8vo. Leeds: Charles Goodall. London: Churchill.

of sewer gas are also shown in section, and from each source of infection curls a ghastly sinuous blue line ending in a forked tail like that of a goblin. We never see the body of this skeleton in the cupboard, this domestic demon, but his scorpion-like tail encircles meat, milk, invalid, and baby alike. If the thing were not strictly true it would be ludicrous, but every plate is given on sound authority; in most cases name and place are duly recorded as means of authentication. Mr. Teale is evidently terribly in earnest. He practically apologises for his method in the familiar quotation from Horace about eyes and ears. But his conviction is none the less contagious; and many a father or mother, after seeing this book (it does not need reading) will set his house in order, in terror of the Visionary Tail.

W. H. STONE.

PHYSICAL SCIENCE.*

THIS can hardly be called a new book, since the lectures on which it is founded were delivered as far back as 1874. But in matter as well as in style it retains a certain freshness which will long prevent its becoming an old one.

The method of its genesis is plainly indicated in the Preface. "The following Lectures were given in the Spring of 1874, at the desire of a number of friends—mainly professional men—who wished to obtain in this way a notion of the chief advances made in Natural Philosophy since their student days.

"The only special requests made to me were that I should treat fully the modern history of energy, and that I should publish the Lectures *verbatim*."

To the history of energy, its conservation, dissipation, transformation, sources and transference, after some introductory remarks, six Lectures are devoted. The transformation of heat into work gives origin to an excellent, lucid, and untechnical account of Carnot's ideas. Radiation, absorption, and spectrum analysis occupy three chapters; the conduction of Heat, with Fourier's Theory, furnish the eleventh; and the last two of the thirteen consider the intimate structure of matter.

Anything like mathematical analysis and even the abstruser parts of scientific terminology seem to be rigidly excluded; on the other hand illustrative experiments of the most apposite and striking kind are freely scattered through the book.

Sir William Thomson's high claims as a discoverer are justly insisted on.

The charm of the book is the extreme neatness with which difficult ideas are brought home to the reader, without any sacrifice of accuracy. A boy in the upper forms of a good school could follow every word, and would thence suck more intellectual nourishment than from "Science in a Teacup," or "Little Experiments for Little Nuisances," and the like.

W. H. STONE.

* "Lectures on some recent advances in Physical Science." By P. G. Pait. M.A., &c. Sm. 8vo, pp. 337. London: Macmillan & Co., 1876.

TREES.*

WITHIN the last few months it has been our pleasant duty to notice two books by Mr. F. G. Heath—the "Fern World" and the "Fern Paradise," and we have now received a third volume by the same author, entitled "Our Woodland Trees," with which we are if possible even more pleased than with the writer's earlier works. It may at first appear, as it did to us, that a popular book on trees was unfortunate in making its *début* at a time

> "When all aloud the wind doth blow,
> And coughing drowns the parson's saw,
> And birds sit brooding in the snow,
> And Marian's nose looks red and raw."

But Mr. Heath is such a thorough enthusiast in his admiration of nature that his new book must, we feel sure, give delight to readers of almost any age, no matter how ungenial their surroundings may be. Though "the leaves have fallen, and lie scattered and dead on hill-side and in hollow, yet trees are lovely still," and Mr. Heath's agreeable and chatty descriptions of English woodland scenery seem actually to bring to one's senses the pleasant scent of the hawthorn and the honeysuckle, even in the midst of trees burdened with snow and glittering in the winter sunshine with pendant icicles. The plan of the book is extremely unpretentious, and it is perhaps to this that it owes its principal charm. Beginning with a brief explanation of the growth of a tree, its structure and its development, in the second part of the book Mr. Heath conducts us on "Some Woodland Rambles" in and about the New Forest; and here it is that he has so favourable an opportunity for the display of his intense appreciation of the charms of English scenery. Lending to the actual beauties of the New Forest an increased and more romantic charm are the innumerable historical associations which cluster around this early Norman hunting ground. And it would perhaps be difficult in the whole of England to select a spot more suitable for illustrating the beauties of English Woodland scenery than that which Mr. Heath has chosen. He speaks, too, with so keen and loving an appreciation of the charming scenery through which he wanders as to carry with him all but the most unsympathetic of readers: the ivy seems to cling kindly round his heart, and the sweet-scented honeysuckle to twine its branches around his imagination—he writes as it were in a bower of wild flowers, and the sweet scents of the forest and the meadow hover with balmy freshness around his pen. A third part of the book is devoted to "trees at Home," and pleads eloquently for the increased cultivation of Trees in the neighbourhood of our town and suburban residences; while the fourth part, occupying not far short of half the volume, consists of descriptions of British Woodland Trees—descriptions which are simple and untechnical, and which may be read and understood by all. While the woodcuts illustrating the earlier parts of the book having been admirably engraved from photographs, or from the drawings of such well-known artists as Harrison Weir

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* "Our Woodland Trees." By F. G. Heath. 8vo. London: Sampson Low, Marston & Co., 1878.

and Birket Foster, need no word of commendation from us, of the coloured plates illustrating the last portion of the work we must speak in high terms. These plates consist of examples of the leaves of common British trees, and have been carefully copied from photographs which reduced the specimens to half their natural size. Nearly all these illustrations are exceedingly good, and the author assures us that exceptional attention was paid to the faithful delineation of the venation; the representations of the conifers in particular are deserving of high praise.

FOLK LORE.*

THERE are few things more curious than the superstitious notions entertained in various places with regard to natural objects and phenomena, and Mr. Thiselton Dyer, taking due advantage of the interest attaching to the subject, has made a very amusing book out of "English Folk Lore." It would require a considerably larger volume, however, to do full justice to such a subject, and we find a good many things omitted which ought to have figured in it. Thus to take only two Shakespearian examples, Mr. Dyer quotes the reference in Hamlet to the disappearance of ghosts at the crowing of the cock, but omits the much more interesting statement that almost immediately follows:—

> "Some say that ever 'gainst that season comes,
> Wherein our Saviour's birth is celebrated,
> This bird of dawning singeth all night long:
> And then, they say, no spirit dares stir abroad:
> The nights are wholesome: then no planets strike,
> No fairy takes, nor witch hath power to charm;"

and again quoting, not directly, the reference to the "toad, ugly and venomous, no mention is made of the "precious jewel in her head," which, we cannot help thinking, many of Mr. Dyer's readers might like to know something about. There are several other references to the toad in Shakespeare which would be deserving of Mr. Dyer's notice when his book comes to a second edition, which we sincerely hope it may soon do. As he has no reference at all to cattle in his present volume, we can furnish him with the following curious superstition which we heard of a good many years ago from an old Essex woman. The cattle in the stalls, according to this authority, always bow their heads towards the east soon after midnight on Christmas morning; and she remembered having been taken, when a child, to witness the ceremony, *but, on the morning of old Christmas Day*, the cattle had resolutely refused to accept the new style. About half Mr. Dyer's book is devoted to the superstitions connected with natural objects, the moon, plants, and animals; the remainder treats of charms, births, deaths, and marriages, the days of the week, the months, and weather, &c.

* "English Folk Lore." By the Rev. T. F. Thiselton Dyer, M.A. 8vo. London: Hardwicke & Bogue, 1878.

SCIENCE MANUALS.

IN these days of scientific school manuals and primers one would have thought that there was hardly room for a new set; but Messrs. Longmans, guided no doubt by a sound knowledge of their own business, have started a series of "Science Class Books," * under the editorial care of Prof. G. Carey Foster and Mr. Philip Magnus. Five of these little books are now before us, only one of which relates to a subject pertaining to the special studies of the editors, namely a treatise on "Hydrostatics and Pneumatics" by the second of them. This, the author tells us, "is intended for the use of those pupils in the upper forms of schools who have already acquired some elementary knowledge of the principles of mechanics," and even without this statement a very cursory inspection of the text sufficed to convince us that it was not intended for beginners, indeed we should hardly have thought that it was designed for the use of schoolboys at all. The information contained in it is of the most accurate and useful description, but from its extreme condensation and the constant use of mathematical formulæ, we should regard it rather as a useful memorandum book for somewhat advanced students than as an ordinary school-class work. We notice that in consideration of the recent discoveries of Messrs. Pictet & Cailletet, the author recognises a more intimate connection between the two branches of his subject than has, we think, usually been admitted.

Dr. M'Nab's treatises on the Morphology and Physiology of Plants and on Systematic Botany, are also intended specially for the use of the upper forms, but the author seems to have at the same time had in view the advantage of still more mature students; in fact, in his preface he specially announces his hope that they may "supply the wants of medical and other students." For these more advanced students they seem to be admirably adapted, and will also furnish an excellent guide for those who are commencing the practical study of plants. All these volumes are copiously and well illustrated.

Of Prof. Macalister's two zoological volumes we can hardly speak in such high terms. Zoology, especially when treated systematically, is so vast a subject, that it seems impossible to give any satisfactory account of it within the compass of two little books of 140 and 130 pages; such a sketch can only be a bare outline, and to make even this satisfactory in its own way the author requires to have a grasp of his subject such as few zoologists can boast. Prof. Macalister has unfortunately attempted to popularise his sketch more or less, and in consequence has in several places conveyed erroneous or imperfect impressions to his readers. Prof. Macalister's volumes are freely illustrated, but the illustrations, many of which are old acquaintances, are certainly not so good as those of the other volumes just noticed.

We may perhaps include under this same heading a series of books pro-

* "The London Science Class Books." Edited by G. Carey Foster and Philip Magnus. Hydrostatics and Pneumatics by Philip Magnus; Botany (2 vols.) by W. R. M'Nab; Invertebrata and Vertebrata (2 vols.) by A. Macalister. Small 8vo. London: Longmans, Green & Co., 1878.

duced by Mr. Thomas Twining* although these are intended more for the guidance and instruction of teachers than as treatises to be read by students. Mr. Twining, as is well known, has devoted much attention to the subject of education, and especially to the diffusion of elementary scientific knowledge among the working classes, with a view to which he got together on his premises at Twickenham an extensive museum of objects and apparatus for the illustration of "the science of daily life." Unfortunately just when this interesting collection was ready to be transferred to a central position in London a fire broke out in the building containing it, and the results of fifteen years' labour were destroyed. In connection with this economic museum while it was still in existence, Mr. Twining prepared a series of lectures, which he has published, preceded by an introduction describing the mode in which he thinks his lectures may be best employed, and giving certain other details in connection with the course of instruction laid down in them, and the best mode of conducting examinations to test the advantage gained by the hearers. The lectures and introduction are published in six parts, which may be obtained separately, each part containing two lectures. Of these three are on Mechanical Physics, one on Chemical Physics, two on Chemistry (Organic and Inorganic), one on the Mineral and Vegetable Kingdoms, one on the Animal Kingdom, and two on Human Physiology, and the series is arranged so as to lead up to the practical application of the last to the purposes of daily life. The idea is an admirable one and exceedingly well worked out, the lectures being at once simple and good, so that they may either be read *in extenso* as the author proposes, or employed to furnish the skeletons of discourses to be filled up in the lecturer's own style. The indications of diagrams and illustrative experiments, of the apparatus for the performance of the latter, and of books of reference for the use of those who wish to supplement the information here given by reading, render this an exceedingly complete and valuable publication, which we can recommend with perfect sincerity to the notice of all school teachers and amateur lecturers on the subjects which it embraces, and also as a reading-book for beginners. We are glad to learn that Mr. Twining's labours in the cause of scientific education have met with due appreciation in Paris, the present series of books having received the honour of a silver medal from the Jury of the recent International Exhibition.

THE GEOLOGICAL RECORD.†

WE have much pleasure in announcing the publication of the third volume of the "Geological Record," which contains an analysis of the geological literature of 1876. The general plan of the work has undergone no

* "Science made Easy; a Series of Familiar Lectures on the Elements of Scientific Knowledge most required in Daily Life. Prepared in connection with the Twickenham Economic Museum, for delivery at popular institutions, for the use of schools and for home study." By Thomas Twining. 4to. London: Hardwicke & Bogue, 1878.

† The "Geological Record for 1876." An account of works on Geology, Mineralogy, and Palæontology, published during the year, with Supplements for 1874 and 1875. Edited by W. Whitaker, B.A. 8vo. London: Taylor and Francis, 1878.

change, but one or two minor modifications have been made in it which in no way affect the usefulness of the "Record" as a work of reference. Appended to the report for 1876, are two supplements containing references omitted in the previous volumes for 1874 and 1875; these of course add to the completeness of the book, but for convenience of reference we cannot help thinking that it would be better to work these supplementary articles into their places in the body of the work, simply indicating by dates in brackets that they belong to previous years. Most of those who consult the "Record" do so to inform themselves as to the literature of some subject in which they are interested, and care little for the historical fact that a certain amount of work was done in a certain year; and it must be borne in mind that, as the number of these supplements increases, there will be a correspondingly increasing difficulty in consulting the volumes for information upon any particular department of geological investigation. We throw out this hint for the consideration of the editor, fully recognising the importance of the service done by him and his coadjutors to their brother geologists, and hoping most cordially that he may realise that seemingly Utopian vision of seeing a copy of his little book, as he modestly calls it, in the hands of every geologist. Considering the value of the work and the low price at which it is brought out, it is a matter of wonder that every year the editor should have to sing the same song with its burthen of "more subscribers wanted."

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

The Wisdom-Teeth and the Evolution of Man.—The results of Prof. Mantegazza's researches on the posterior molar teeth in man, which are briefly referred to by Mr. Darwin in his "Descent of Man," have appeared in a memoir entitled "Il terzo molare nelle razze umani," published in the last number of the "Archivio per l'Anthropologia." These researches were undertaken to test the soundness of the view put forward by Mr. Darwin that "the posterior molar or wisdom-teeth were tending to become rudimentary in the more civilised races of man," and the rich craniological collection in the national museum at Florence, which has been carefully examined by Prof. Mantegazza, must have afforded ample materials on which to found an opinion. After rejecting those skulls which were too old, too young, or too imperfect to permit of useful investigation, no less than 1,249 skulls passed through Prof. Mantegazza's hands, of which 844 were those of modern highly-civilised races, 277 those of modern inferior races, and the remaining 128 belonged to Romans, Etruscans, Phœnicians, and other nations of antiquity. From the investigation of these skulls he finds that the wisdom-teeth are more frequently wanting in the superior than in the inferior races of man, the proportion being 42·42 per cent. in the higher against 19·86 per cent. in the lower types, which result agrees entirely with Mr. Darwin's view. Prof. Mantegazza, however, finds that atrophy of the third molar occurs less frequently in the higher than in the lower races, the proportion in this case being 10·90 per cent. in the higher to 20·58 (or very little short of double) in the lower types. While in the lower races the abnormal and normal cases are virtually equal (the figures being 50·44 in the latter and 49·46 in the former), with the higher races the fact is found to be very different, there being no less than 62·91 per cent. of abnormal to 37·09 per cent. of normal teeth. The crania of ancient types appear to stand intermediate between the higher and lower races of modern times, exhibiting 27·34 per cent. of skulls in which third molars are wanting, and 16·41 per cent. in which they are atrophied. With respect to the number of fangs possessed by wisdom-teeth, Prof. Mantegazza's investigations show that these teeth have three roots in 51·35 per cent. of the skulls of modern high races, in 45·20 per cent. of modern low races, and in 46·43 per cent. of ancient types. While wisdom-teeth with four and with two fangs were found to be more common in the modern high races than in any others,

teeth having but a single root are of more frequent occurrence in the skulls of lower types, and in only one case was a wisdom-tooth with five fangs observed, in a modern skull of high type. As an almost invariable rule the third molar of the lower jaw was found to possess two roots, though occasionally in the higher types four roots were observed. The result of Prof. Mantegazza's investigations strongly corroborates the view put forward by Mr. Darwin, and leads the Professor to believe that at some future period the third molar may permanently disappear from the human jaw.

The Colour of Human Hair.—In a paper published in the August number of the "Journal of the Anthropological Institute," Mr. H. C. Sorby has described the results of some investigations in which he endeavoured to separate the pigments contained in the hair, and to subject them to a chemical and spectroscopical examination. His researches lead him to the conclusion that hair is a colourless horny substance, the tint in different specimens being due to the presence of three or perhaps four distinct pigmentary bodies. These pigments being protected by the horny matter of the hair, are unaffected by water, alcohol, and other common solvents, and sulphuric acid more or less dilute appeared to be the best medium for separating the colouring principles, though, by its agency, it was possible that decomposition might be effected, and products be thus formed which were not originally present in the hair. This small difficulty was, however, one with which so experienced an analyst as Mr. Sorby would have no trouble in grappling. From the different kinds of human hair which he examined he obtained a reddish, a yellow, and a black pigment, the first of which, being an unstable body, may possibly pass into yellow by a process of oxidation. In bright red hair the red constituent was found to be present unaccompanied by other pigments; while dark red hair contains a certain proportion of the black colouring matter. Golden hair contains less red and more yellow colouring matter, while in hair of a sandy tint a proportion of the red and black principles are associated with a large quantity of the yellow pigment, and in dark brown hair the black principle increases, and the yellow and red are greatly reduced in quantity; until in black hair the two latter substances almost disappear, being replaced by the black pigment. In some cases, however, as in that of the black hair of a negro, the black colouring matter was accompanied by a quantity of the red pigment, equal in amount to that found in the bright red hair of Europeans, which leads to the conclusion that had the supply of black pigment failed from any cause, this negro's hair instead of being white would have been of as bright a red as the hair of the most typical Celt.

Osteology of the Achinese.—An Achinese skeleton, doubtless the first which has ever reached Italy, has lately been presented to the Anthropological Museum at Florence, and forms the subject of "Studi Anthropologici intorno ad uno Scheletro Accinese," published by Dr. Ricciardi in the "Archivio per l'Anthropologia." The people inhabiting the interior of Achin, in the northern part of the Island of Sumatra, differ in many important respects from the neighbouring Battas or Battaks, and have sometimes been regarded as a "cross" between the Battak and Malay types. The skull examined by Dr. Ricciardi agrees, however, most closely with that of a Battak, and has a cephalic index of 76·24, so that it belongs to the orthocephalic group of

Professor Huxley or to the subdolichocephalic group of Broca. It is to be observed that the only skulls coming from Sumatra with which Dr. Ricciardi was able to compare his specimen were seven described by Dr. Barnard Davies in his "Thesaurus," and amongst these there is not a single example of an Achinese skull. On comparison with the skulls of Javanese, Dyak, Papuan, Malay, and Chinese the measurements of the Achinese cranium were found closely to agree with the Dyak, but to differ in many important respects from the Malay; while there is a certain amount of agreement between it and the Chinese skull, though it differs materially in the character of the orbits, facial bones, and upper jaw. Interesting as the description of this skeleton must prove to anthropologists, it must be remembered that from a single specimen it is unsafe or rather impossible to draw any sound conclusions, as the peculiarities observed may be due, not to specific variations but to an abnormal development of the individual.

ASTRONOMY.

Photographs of the Total Solar Eclipse of July last.—Mr. Ranyard thus presents the results of photographic work during this eclipse:—"The photographs taken by Dr. Brackett during the recent eclipse with a six-inch telescope of rather more than seven feet focal length, seemed, as far as I could judge, to be equally dense with the photographs of similar exposure of Lord Lindsay's and Colonel Tennant's series, taken in India, 1871. I speak with some caution, as I have not had an opportunity of comparing the negatives side by side; but the density of the Indian negatives is very well impressed on my mind, as I spent more than a year in making out and cataloguing the details which are visible upon them. It must be borne in mind, that during the Indian eclipse, the sun, as seen from the two photographic stations, was at a lower altitude than as seen at Denver, Dr. Brackett's station; but while the angular aperture of Dr. Brackett's instrument was less than one in fourteen, Lord Lindsay's and Colonel Tennant's cameras were of four inches' aperture, and about thirty inches focus, or one in seven and a half—that is, in the two Indian cameras, which were of similar construction, the pencil of light falling on an element of the plate, was nearly four times as intense as the pencil falling on a similar element in Dr. Brackett's telescope camera. We have no data, of course, for comparing the diactinism of the Indian and Colorado atmospheres. But we may, I think, feel justified in asserting that as far as the evidence derived from the photographs of 1870, 1871, and 1876 goes, the corona does not wax and wane with sun-spots. In fact, the corona with by far the greatest equatorial extension is found at a period when there are hardly any spots upon the sun's disc, and it should also be remembered that the difference between the coronas of 1870 and 1871 does not at all correspond with the development of sun-spots at the two periods."

Polarisation of the Corona.—Mr. Schuster notes that the polarisation of the corona seems at first to increase with distance from the sun, and then to decrease rapidly. Doubtless, the explanation suggested by Mr. Ranyard is the correct one. Near the sun the matter of the corona is in-

candescent, and the light from it is in large part unpolarised; on the other hand, the light from the outer part of the corona is mixed up with light from our own atmosphere, drowning the polarisation of the outer corona.

Meteoric Theory of the Corona.—Mr. Penrose infers from the observed aspect of the coronal streamers that they are due to meteoric systems. "I am far from arguing," he says, "that this theory answers for the whole of the corona, and I much doubt whether it will explain the almost equal and radial lines which proceeded from the neighbourhood of the sun's north pole, and which appeared to me the most beautiful part of the whole. There was also something analogous near the sun's south pole, but not so clearly radial. The pointed ends of the 'wind vane' (a name suggested by the shape of two opposite sets of streamers) seem to suggest the explanation of an elliptic orbit of considerable major axis and great eccentricity. The wedge-like point proceeding from the north pole of the sun would agree with a similar figure, whilst some of the others can be explained by orbits of meteors of less extent. It is obviously not requisite that the sun's centre should be the focus of the apparent orbit, as it would be modified from the real figure by perspective."

Foreign Observations of Meteor Showers.—From observations recorded by Heis, Weiss, Schiaparelli, Zezioli, and Konkoly, Mr. Denning has drawn up a useful list of 79 meteor showers in the Notices of the Astronomical Society for November. We observe that he still fails to recognise the validity of the objections raised by Captain Tupman and others, against his idea that meteors belonging to the same system can appear to radiate from the same point in the sidereal heavens for several successive weeks. He seems to suppose that planetary perturbations acting on attenuated meteor streams might diffuse them, so that a considerable time would be required for the earth's passage through them, while the radiant points remained sensibly unaltered. He says it "has yet to be ascertained" whether this is possible. But nothing can be more certain than that this is utterly impossible. He appears also to suppose that the results of observation are questioned by Captain Tupman and the other objectors. "Observers will state the legitimate result of their labours," he says, "apart from theoretical considerations, however incompatible they may at first appear." It was to his interpretation of his results that exception was taken, not to the results themselves. If observers have obtained clear evidence showing that at different times between the middle of October (to take one case) and the middle of December, meteors radiate from the same point of the stellar heavens, their statement must be accepted. But when they proceed to assert that, therefore, the meteors so seen belong to one system, the mathematician perceives that the inference is entirely erroneous. It is absolutely certain, if the results of observation are admitted, that the meteors belong to different systems. The reasoning runs simply thus:—We know that the members of a meteor system are bodies travelling around the sun in orbits passing near the earth's; and that their "radiant" at any given date is a point depending on the combination of their motion with the motion of our earth, the direction as well as the velocity of each motion being involved. If, then, it were possible for a meteor system to be so widespread that the earth required eight or nine weeks to pass through it, and even if the directions of the meteors at all parts of her arc of

passage were roughly parallel, yet, as the direction of the earth would change through about sixty degrees, the position of the radiant would change markedly during those eight or nine weeks. But observation, it seems, indicates the same "radiant." Hence it is certain that the meteors belong to different systems. We could, in fact, only accept Mr. Denning's inference if we rejected his observational results.

Observations of Jupiter and his Satellites.—Mr. Todd presents a very valuable and interesting series of observations of Jupiter and his satellites, with the Adelaide equatorial, in the Monthly Notices for November. "The visibility of the satellites through the edge of the planet has been carefully looked for," he says, "and on two occasions I felt quite certain I saw the satellite at occultation within the disc—namely, on June 19 at occultation-disappearance of Satellite II., and on July 2 at disappearance of Satellite I. Mr. Ringwood also saw the same phenomenon at the disappearance of Satellite II. on August 29. I thought I could see Satellite III. through the limb at reappearance on June 9, and Satellite II. at disappearance on July 21, but could not be certain. In every other case the occultation was perfect at the limb. On June 19, Satellite II. was visible through the white belt south of equator, and on July 2 Satellite I. was seen for the space of one minute through the southern dark belt. It would be interesting to know whether this has been seen by other observers. The definition on each occasion was very good, or I should think I might be deceived." The observation on July 2 is a very singular one. Mr. Todd's notes say that "the satellite was distinctly seen through the edge of the planet *for the space of its full diameter*."

Tempel's Short Period Comet.—This comet, as observed at the Oxford University Observatory from July 27 to August 1, resembled a faint round nebula of about 1′ in diameter. The condensation was very slight.

Encke's Comet.—This comet was observed by Mr. Tebbutt, at Windsor, New South Wales, from August 3 to August 13. On August 3 it presented the appearance of a small round nebula, gradually condensed towards the centre, and was within a few minutes of arc of the position assigned to it in the ephemeris.

Intra-Mercurial Planets.—From a comparison of his own and Professor Watson's observations of stars near the sun during the last total eclipse, Professor Swift arrives at the conclusion that four intra-Mercurial planets were seen on that occasion—two by himself and two by Watson. He considers that both the stars he himself saw were planets, since, if one of them had been, as he before supposed, the star Theta Cancri, Watson could not have failed to see the other. For a similar reason neither of them can have been the object which Watson saw near Theta Cancri. The other object, which Watson at first mistook for Zeta Cancri, is now regarded by him very confidently as a planet. Accordingly, it would follow that four intra-Mercurial planets were seen by these two observers, and that all were so situated as to present appreciably round discs. Other observers, who with equal or better means sought specially for such planets, would seem to have been singularly unfortunate.

The Annular Eclipse of January 22, 1879.—Mr. Hind states that this eclipse, the first of the annular eclipses of 1879, and a return of that of January 10, 1861, which was central in Australia, commences in Uruguay,

whence the belt of annular phase traverses the South Atlantic, passing over Tristan d'Acunha, the few inhabitants of which islands may probably be startled by seeing the sun transformed into a narrow luminous ring, while he is high in their heavens. The central line crosses the African continent in the direction of Pemba Island, north of Zanzibar, where the annularity will continue nearly three minutes; the middle of the eclipse occurring at 4h. 6m. P.M., local mean time.

Comets of Short Period.—Prof. Schuler states that Brorsen's comet will arrive at perihelion on March 30, 1879. It is probable that the comet will be first observed in the southern hemisphere. About six weeks later Tempel's comet 1867(II.), which was reobserved in 1873 (after undergoing great perturbation from the planet Jupiter), will be due at perihelion. "The elements deduced from the observations of 1873 alone," says Mr. Hind, "would assign, without taking account of perturbation, April 26, for its perihelion passage; but according to an orbit just published by M. Raoul Gautier, of Geneva, which he says may be considered the most probable one till the observations to be expected next year afford additional means of determining the mean motion, the comet would not be in perihelion till May 8; in which case its apparent track in the heavens will differ little from that which it pursued in 1873, when it arrived at its least distance from the sun on May 9. It is pretty sure to be always a faint object except for the larger telescopes; and considering the uncertainty which still appears to exist regarding the mean motion at its last appearance, a close search may be necessary for its rediscovery. M. Gautier is calculating the effect of Jupiter's attraction during the actual revolution, with the intention of publishing an ephemeris in due time: this effect, however, must be small, as the comet has not been nearer to the planet than 1·5 (earth's distance from the sun being 1) "during the interval."

Sun-spots and Commercial Panics.—Among the many absurdities which the advocates of national solar observatories have invented, none is more absurd in itself, or more flatly contradicted by evidence, than the singular theory that commercial panics usually occur near the epochs of sun-spot minima. We know the dates of sun-spot maxima and minima since 1700, in every case within a year or so. We have also the list of commercial panics ingeniously prepared by Prof. Stanley Jevons to accord with the doctrine that the sun-spot period has an average value of 10·46 years; and instead of the asserted agreement between sun-spot minima and panics, we find more than half of Jevons's panics occurring nearer to sun-spot maxima than minima. Two of the most remarkable panics occurred almost exactly at the time of maximum solar maculation. The advocates of expensive new observatories seem to imagine that no one will be at the pains to analyse the evidence they offer. But, though the theory of special sun-spot influences is no doubt too absurd to be seriously dealt with, the arguments offered, with seeming seriousness, in its favour, are not likely to escape criticism altogether. No one would seriously try to prove that the panic of 1866 did not occur for want of sun-spots that year; but when the panic of 1815 is associated with a sunspot minimum, science may, without absurdity, just throw in the remark that 1815 was a year of maximum not of minimum sun-spottedness.

Planetary Phenomena, &c.—Uranus will be in opposition to the sun on February 21 at 4 A.M. Mercury will be at greatest elongation west on January 16, east on March 20.

BOTANY.

Sensitive Organs in the flowers of Asclepiads.—Dr. J. Gibbons Hunt communicated to the Academy of Natural Sciences of Philadelphia, on the 27th of August last, some observations on the flower of *Asclepias asterias*, which he had been informed by Mr. Isaac Buck was probably a fly-catcher. The odour of this flower, which is exceedingly disagreeable to human olfactory organs, appears to be very attractive to flies, many of which were watched by Dr. Hunt "eagerly applying their tongues all over the petals and essential organs, apparently eating with almost intoxicated relish the attractive excretion covering those parts." They continued to indulge freely in this banquet until they happened to touch one of five black spots placed alternately with the stamens, when the fly was immediately seized and held fast by his proboscis. In the struggle that ensued the fly, if small and weak, would be held fast in the trap; if large and strong he would make his escape, but burdened with the trap and with a pair of pollen-masses attached to the latter. The adhesion of the fly's proboscis to the black spots is not due to any sticky fluid; but it is caught by an organic structure, the action precisely resembling that of an ordinary rat-trap. The sensitive black discs may be set in action by contact with a bristle.

Analogous arrangements occur in other genera of the *Asclepiadeæ*, and on the same occasion Mr. Edward Potts gave an account of his observations on two species of *Asclepias* (*A. incarnata* and *curassavica*) in which similar phenomena take place. The sensitive organs are placed immediately below the anther-sacs in shallow depressions upon the perpendicular ridges of the stigma. Two pollen-masses are attached to each clasping organ by long bent filaments, and these are withdrawn from the anthers when the organ has clasped the leg of an insect, a bristle, or a small camel-hair pencil. As evidence in support of this arrangement being destined to cause cross-fertilization, Mr. Potts mentioned his having found upon flowers of *Asclepias curassavica* foreign sensitive organs with their attached pollen-masses, which must have been brought there by some external agency. In each case one mass of the introduced pair was inserted under the edge of the anther of the flower, so as to come close against the sloping lower surface of the stigma; the flowers thus intruded upon persisted longer than others of the same group, and on dissection it was found that each of the inserted pollen-masses had sent out a profusion of pollen-tubes towards the junction of the stigma and the style.

A Catalogue of British Plants.—We understand that the Rev. George Henslow, F.L.S., is about to print a catalogue of British plants arranged according to "Hooker's Students' Flora." Anyone wishing for copies is requested to communicate with him, at No. 6 Titchfield Terrace, Regent's Park, N.W.

The "Pro-embryo" of Chara.—In the "Journal of Botany" for July last Mr. A. W. Bennett, writing on the systematic position of the *Characeæ*, proposes to unite that order with the *Muscineæ*; later Prof. Caruel assigned it a position between the vascular cryptogams and the phanerogams; and in a still later paper Mr. Sydney Vines looks upon it as an independent group, intermediate between the *Carposporeæ* and the *Muscineæ*. Both Mr.

Vines and Mr. Bennett agree that it is incorrect to place the *Characeæ* among the *Carposporeæ*, since they have stronger affinities with the mosses, with which the latter proposes to unite them. In this view, however, Mr. Vines does not concur. He holds "that a well-marked alternation of generations occurs in the life-history of the *Chara*, and that the *Chara*-plant with its reproductive organs is the oophore, the sporophore being represented by the embryo—*i.e.*, the product of the development of the central cell of the archegonium. In order to indicate the fact that no spores are ever produced, so far as is at present known, by the sporophore of *Chara*, we may speak of this plant as being 'aposporous,' using a word which is symmetrical with the term 'apogamous,' applied by De Bary to those ferns in whose life-history no process of sexual reproduction occurs."

On the Kind of Light required by Growing Plants.—In the *Comptes Rendus* of November last M. Paul Bert gives the results of his experiments on the action of coloured light on vegetable life. He found that, while plants covered with green glass shades stopped growing and quickly died, those covered by panes of red glass continued to live and grow, though with diminished vigour. On submitting the coloured panes of glass to spectroscopic analysis with an illumination equal to diffused sunlight, he found that the red glass intercepted the yellow and all the more refrangible part of the spectrum, only the orange and red rays passing through, while the green glass permitted all but the least refrangible three-fourths of the red rays to traverse it. Hence it appears that the light essential to the continuance of plant life must be included in that portion of the red which is absorbed by the green pane. In order to further define its limits M. Bert compared the absorbent effect of the green glass with that of a dilute solution of chlorophyll, which was found to stop only a small part of the red rays, namely those situated between B and C. M. Bert then constructed a case with double walls of colourless glass, the space between the walls being filled with the chlorophyll solution, and it was found that plants kept in this case, though freely exposed to light, not only ceased to grow, but died as rapidly as those put under green glass shades. Thus the exact nature of the light rays indispensable for the support of vegetable life was determined, and it would appear (though proof is still wanting) that the regions of the spectrum capable of being utilised by plants are precisely defined by the various absorption-bands of chlorophyll.

CHEMISTRY.

The Crystallisation of Silicic Acid in the Dry Way.—In 1868 Vom Rath found on a specimen of trachyte a variety of silicic acid which differed both in form and density from quartz; it was shown, in fact, that silicic acid, like sulphur, arsenious acid and antimonious acid can crystallise in two distinct forms. Hautefeuille now finds that this compound can be crystallised artificially in the dry way in these two different forms. Rose, who was the first to prepare the acid in the crystallised condition, obtained it, when a salt of phosphoric acid was employed in the form of tridymite. If amorphous silicic acid and tungstate of soda be retained for a long time at the fusing

point of silver, and the tungstate be extracted from the fused product by water, the insoluble portion has the appearance of a crystallised sand, and has within a few milligrammes the weight of the silica employed; that it is converted into tridymite is proved by the form and optical characters of the crystals. By protracted heating, larger crystals are formed. They have a specific gravity of 2·30, that of the natural crystals which Vom Rath examined, and which contained about 2 per cent. of metallic oxides, being 2·32, 2·31, and 2·29. If a heat higher than 1,000° be applied the crystalline plates dissolve in the tungstate, and a silicate is formed which floats in the melted salt; while at temperatures less high, at 900° or lower, tridymite crystals separate. It is evident that the alkali of the tungstate attacks the silica and forms with it an alkaline silicate, tungstic acid being set free; as the temperature falls it again combines with the alkali, and the silicic acid is liberated in the crystalline form. The reaction appears to take place at lower temperatures than in the case where a phosphate is used. If the fused mass already referred to be retained at a lower temperature—nearer, in fact, to its melting-point—at about 700°, transparent elongated bodies are formed; if the heating be continued for several hours, double pyramids of quartz are noticed which become strongly coloured when viewed between Nicol's prisms. The crystallisation in this case was found to proceed slowly, the action being more rapid when the temperature rose and fell frequently between 800° and 950°. Each time the mass cooled tridymite was formed; as soon, however, as the temperature fell below 850° quartz crystals made their appearance. In one instance, where the heating was prolonged for two months, about equal quantities of silicic acid had crystallised as quartz and as tridymite. The specific gravity of the mixed crystals was 2·46, a number intermediate between those representing the density of tridymite (2·30) and of quartz (2·65). In one instance, the greater part of the tridymite was mechanically separated, and here the number rose to 2·61. Analysis showed the crystals to contain 0·003 of soda and a mere trace of tungstic acid.—*Comptes Rendus*, 1878, vol. lxxxvi. pp. 1133 and 1194.

Philippium and Décipium.—Delafontaine announces the discovery of two metals to which he has given the above names. The former occurs in samarskite; its oxide is yellow, like terbia, and has a molecular weight intermediate between those of yttria and terbia. He has satisfied himself that it is not a mixture of those two bodies, and gives the new metal the name Philippium in honour of M. Philippe Plantamour, of Geneva. The formiate of philippia is less soluble than the corresponding salt of yttria, and its oxalate is more readily soluble in nitric acid than the corresponding salt of terbia. A concentrated solution of a salt of philippium shows a fine absorption band in the indigo ($\lambda = 450$ nearly), two in the green, a faint one in the blue, and one in the red. (*Comptes Rendus*, 1878, vol. lxxxvii. p. 559.) A fortnight after the publication of this note, Delafontaine announced (*Ibid.* p. 632), the discovery of a second metal in the samarskite of N. Carolina, and this he has named Décipium. It forms an oxide, the equivalent of which is close upon 122 for the formula DpO (or $Dp_2O_3 = 366$). The acetate is less soluble than that of didymium, and more so than that of terbium; the décipio-potassium sulphate is only slightly soluble in a concentrated solution of potassium sulphate, but easily soluble in water. The absorption

spectrum of the nitrate exhibits three bands at least in the indigo and blue. The most refrangible band is a little smaller than that of philippium, or the *m* of didymium. It occupies a space between Fraunhofer's lines G and H, being rather nearer to G, at a point where didymium and terbium show no lines; then there are two bands in the violet which appear to be H and H′. References to the wave-lengths of these and other bands will be found in the author's paper. The North Carolina samarskite has now been shown to contain the following earths:—

Name.	Equivalent.
Yttria	$YO = 74·5$
Erbia	$ErO = 130$
Terbia	$TbO = 114–115$
Philippia	$PpO = 90$ (about)
Décipia	$DpO = 122$ (about)
Thorina	$ThO_2 = 267·5$

as well as the oxides of didymium and cerium. Delafontaine traces the following interesting relation between the equivalents of some metals of this group:—

Yttrium	58	
Philippium	74	$= 58 + 2 \times 8$
Terbium	98	$= 58 + 5 \times 8$
Décipium	106 (?)	$= 58 + 6 \times 8$
Erbium	114	$= 58 + 7 \times 8$

Mosandrum.—According to J. L. Smith, a new metallic element, to which he has given the above name, occurs in some of the native columbates. He refers to it in a paper published July last in the "Comptes Rendus" (1878, lxxxvi., 148) on the analysis of these minerals. He directs attention to the action of concentrated hydrofluoric acid on the samarskite and euxenite of West Carolina, which is as rapid and energetic as that of hydrochloric acid on calc-spar. By the application of the heat of the water-bath the powdered mineral can be completely broken up in a few minutes. He finds that the earths of the yttria group present in these minerals consist of one-third erbia and two-thirds yttria. The group contains no cerium, but nearly 10 per cent. of thorina, a small quantity of didymium oxide, and 3 per cent. of an earth which he believes to be new to science. He makes the atomic weight of the new earth to be 109 (when O = 16), those of oxide of cerium and lanthanum being 110, and of oxide of didymium 112, according to Marignac. The new oxide is stated to differ from the earths of the yttrium group as regards its reaction with potassium sulphate; from cerium oxide by its being soluble in very dilute nitric acid, or in an alkaline solution through which chlorine has been conveyed; from didymium oxide by its colour as well as in other features, especially the absence of the characteristic absorption bands; and from lanthanum oxide by its colour, the crystalline form of the salts, &c. It appears that the discovery was communicated to the Academy of Sciences more than a year ago, and publicly announced at Philadelphia in May last year. Marignac, who can speak with authority on the question, does not find in any of the reactions quoted by the discoverer sufficient reasons for distinguishing the earth in question from terbia. He finds that the sulphate

of mosandrum can be redissolved in an excess of potassium sulphate. It is less soluble than yttria and erbia are; and this is, in fact, a characteristic of terbia, as pointed out long since by Delafontaine.

A New Organic Base in Animal Organisms.—During the last twenty-five years many observers have described some peculiar crystals which are to be met with in certain organs of the animal body as well as in such fluids as blood, saliva, pus, &c., both in health and disease. Charcot, in 1853, was the first to draw attention to them, and by many writers they are spoken of as "Charcot's crystals." Some have supposed them to be tyrosine, others phosphate of lime, and others again a compound allied to albumen. Schreiner has now shown ("Annalen der Chemie," 1878, c. xciv., 68) that they are the phosphate of a new base. The pure substance has marked alkaline properties, and forms little groups of crystals resembling wavellite. It dissolves in absolute alcohol, and is only slightly soluble in ether; when heated with a solution of potash or soda it evolves ammonia, and gives a flocculent white precipitate with zinc chloride. The hydrochlorate forms a double salt with platinum chloride, which separates in large prismatic crystals; the double salt of gold is also a crystallised body. An analysis of the hydrochlorate of the base gave numbers which point to C_2H_5N,HCl as the formula of this salt. A second paper by the author will shortly appear.

Iron Phosphide.—Percy observed that iron will not take up more than 8·4 per cent. of phosphorus when those substances are heated together. J. E. Stead, in a paper recently read before the Cleveland Institution of Engineers ("The Chemical News," 1878, xxxviii., 14), states that he has succeeded in obtaining combinations of phosphorus, varying between 6 and 27 per cent. The point of fusion of the compound is lowered with each addition of the metalloid until a substance containing from 10 to 12 per cent. of phosphorus is produced, after which each addition makes the compound less and less fusible. Iron phosphide containing 11 per cent. of phosphorus is quite fluid at a bright red heat; the compound with 25 per cent. is infusible at that temperature. If a partially-fused pig of Cleveland iron be broken across, the fractured surface "presents throughout glistening, apparently fluid, portions, thoroughly interspersed with particles of metal which have not become fluid." Stead poured one cwt. of Cleveland iron into a mould and, when on cooling it had become viscous, he applied great pressure to it by means of a hydraulic ram. Below are given the composition of the iron itself (I) and that of the last portions of fluid metal expressed from it (II):—

	I.	II.
Iron	93·125	90·122
Carbon	3·000	1·750
Manganese	0·355	0·288
Silicium	1·630	0·790
Sulphur	0·120	0·060
Phosphorus	1·530	6·840
Titanium	0·240	0·150
	100·000	100·000

The latter may be regarded as a mixture of iron phosphide, and unaltered pig; and a calculation of the amount of the last-named constituent, based on

the quantity of silicium present, shows the mixture to consist of 48·5 per cent. of pig iron and 51·5 per cent. of a phosphide composed of

Iron	88·05
Phosphorus	11·95
	100·00

A second similar experiment, made six months later, gave numbers which point to the fusible phosphide having the composition

Iron	88·26
Phosphorus	11·74
	100·00

It appears, therefore, to possess a definite composition corresponding to the formula Fe_4P.

Nodules from the Deep Sea.—Gümbel publishes an interesting and very complete analysis of some of these nodules. Between Japan and the Sandwich Islands the sea-bed is covered with red mud, fragments of pumice, and the so-called "Manganese nodules." Those which he examined had been dredged up by the "Challenger" from a depth of 2,740 fathoms. They are rounded or flattened, have a dull brown colour, and enclose particles of pumice, teeth of fish, &c. The nodules scale off in layers, and a careful inspection of cross sections convinced the author that the structure is due to mechanical action, and not to the agency of any organism. The pumice is trachytic. He is of opinion that the material constituting the nodules has been derived from submarine sources. A very complete analysis of a fragment of one of these interesting bodies was made, and it was found to have the following composition:

Iron sesquioxide	27·460
Manganese peroxide	23·600
Alumina	10·210
Lime	0·920
Magnesia	0·181
Soda	2·358
Potash	0·396
Baryta	0·069
Silicic acid	16·030
Titanic acid	0·660
Sulphuric acid	0·484
Carbonic acid	0·047
Phosphoric acid	0·023
Chlorine	0·941
Copper oxide	0·023
Nickel (cobalt) oxide	0·012
Water	17·819
	101·233

The low proportion of carbonic acid present in these nodules is very year. :kable (*Sitzungs-Ber. baeyer. Akad. Wiss.* 1878, 2.)
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GEOLOGY AND PALÆONTOLOGY.

Crabs in the Coal-measures.—Hitherto the Brachyuran, or short-tailed Crustacea, have been regarded as of comparatively recent origin. Most of the known fossil forms have been obtained from Tertiary beds; and of the few Secondary species the most ancient appears to be one from the Forest Marble of Malmesbury, Wiltshire, described by Dr. H. Woodward under the name of *Palæinachus longipes.* A specimen just described by the same distinguished palæontologist carries the group of short-tailed Decapods or crabs much further back in time; it is the tail or abdomen of an animal of this group from the coal-shale near Mons, in Belgium. This abdomen, which is preserved upon a slab of shale bearing impressions of the ferns *Neuropteris heterophylla* and *Alethopteris lonchitidis,* is about half an inch long, and nearly perfect. It consists of seven segments more or less completely anchylosed together as in the Leucosiidæ; its general form is oval, truncated at the base where it was attached to the cephalothorax. The central part or axis of the abdomen consists of a large trapeziform basal segment, having a large tubercle on each side of the middle line, and three small impressed points near the middle of the hinder margin, followed by five smaller, transversely oblong segments, gradually diminishing towards the apex, and each marked with three points corresponding to those in the first segment. The seventh or last segment is again of large size, and widens in a fan-like form towards the extremity of the tail. The lateral portions of the tail, completing its general oval form, are ornamented with tubercles, a distinct row of which accompanies each line of division between the different segments, and runs out to the edge of the abdomen, where each divisional line terminates in a slight projection, giving the margin of every segment a gently concave form. For this crab Dr. Woodward proposes the name of *Brachypyge carbonis.* It furnishes the first clear evidence of the existence of true crabs during the coal-measure era, although Dr. Woodward states that he has received from Mr. M'Murtrie fragments apparently of Brachyura found in the Radstock coal-field, near Bristol, and at the Pendleton colliery, near Manchester.—*Geological Magazine,* October, 1878.

A New Order of Fossil Rhizopods.—Prof. P. Martin Duncan describes (Ann. Mag. Nat. Hist. October, 1878), some spheroidal bodies obtained in the Karakorum mountains, which he regards as indicating a new order of Rhizopods. The fossils are calcareous, and present no traces of having been attached during life; their surface presents rounded or wart-like elevations, and sometimes depressions resembling large pores; and they measure from one to three inches in diameter.

The surface consists of a close reticulation of minute tubes, of the openings of such tubes, and of interspaces between the tubes. Internally the fossils consist of tubes from $\frac{1}{300}$ to $\frac{1}{1000}$ inch in diameter in limited radial groups, which are separated by a reticulation of inosculating tubes, such as are seen on the surface. The radial groups of tubes form cones with the apex towards the centre, and the base usually forming one of the eminences on the surface of the fossil. The interradial tubes are derived from the radial ones, and the walls of all the tubes are composed of opaque, granular, irregular, semi-spiculate-looking, and very minute particles of carbonate of lime.

There are no diaphragms, intertubular structure, or cœnenchyma; the spaces between the tubes are filled, in the fossils, with calcite, which also occupies the tubes. The course of the radial tubes is sometimes straight; but usually they bend suddenly and repeatedly, and then pursue a straight course. They divide repeatedly.

Of these curious and exceedingly problematical fossils, which he says are not crinoids, corals, sponges, or Foraminifera, Prof. Duncan proposes to make a new order, Syringosphæridæ, and in it he distinguishes two genera:—*Syringosphæra* with eminences and pores on the surface, and *Stoliczkaria* without pores.

Silurian Land-plants.—In September, 1877, Count Saporta described a fern from the slaty schists of Angers under the name of *Eopteris Morierei.* He now (*Comptes Rendus,* 18 November, 1878) describes further evidence of the existence of ferns at the time of deposition of these rocks, referred to near the base of the Middle Silurian. His new material is the impression of the frond of a fern nearly 9 inches long, and about 3 inches in average width. It shows a slender rhachis bearing 7 pairs of leaflets, which are opposite or nearly opposite, of a rounded oval form, traversed by fine, divergent, flabellately dichotomous veins. These leaflets are sessile upon the rhachis, or nearly so. Beyond the seventh pair the apex of the frond is formed by a terminal leaflet, which appears to be round or reniform, folded upon itself, and perhaps composed of two portions partially soldered together. M. de Saporta names the species *Eopteris Criei,* after its discoverer, M. L. Crié.

Dwarf Crocodiles of Purbeck age.—Prof. Owen, in a paper read at the opening meeting of the Geological Society this session, described some diminutive crocodilian remains found in rocks of Purbeck age, which must have been contemporaneous with the well-known mammals of small size characteristic of these strata. In some slabs of "feather-bed" marl accompanying the Becklesian collection of Purbeck fossils in the British Museum, have been found in considerable abundance the remains of these dwarf crocodiles, to one of which Prof. Owen has given the name of *Theriosuchus pusillus.* This crocodile appears to have been only about eighteen inches in length. It had its scales connected by the "peg and groove" arrangement, as in *Goniopholis,* with which genus it also agrees in many of its cranial characteristics, while in dentition it approaches more nearly to the Triassic Theriodonts than any other crocodiles.

Lithology and the Classification of Crystalline Rocks.—Prof. Dana has just completed a memoir "on some points in Lithology," and the conclusions at which he arrives seem to be of such importance that we here reprint them. He says the principal points brought out in his paper are the following:—

1. The necessities of the science of Geology constitute the most prominent motive for distinguishing *kinds* of rocks; and they should determine to a large extent upon what characters distinctions should be based.

2. In determining the rocks to be grouped as one in *kind* under a common name, near identity in the chemical and mineral composition of the chief constituents is the main point to be considered; not near identity in their crystalline forms, for isomorphism presupposes diversity of composition.

3. Distinction of *kind* should be based on difference in chemical and

mineral constitution as regards the chief constituents. When such difference exists, rocks are different in *kind*, and need, for the purposes of geology, distinct names. If it does not exist, the distinction is only that of *variety*, unless (as in the case of trachyte and felsyte), the very wide extension of the rock under persistent characters makes a distinction of name important to geology.

4. It follows from the preceding that differences in texture: as coarse, or fine, or aphanitic; porphyritic, or non-porphyritic; stony throughout, or having unindividualised portions among the stony grains; and differences in microscopic inclusions; are no basis for a distinction of *kind* among rocks, but only of variety, and that *porphyritic structure* is of hardly more consequence than coarse or fine granular.

5. No marked change in the constituents of the earth's erupted material occurred after the close of the Cretaceous period, or just before the commencement of the Tertiary era; and, hence, no gronnd exists for the distinction of "older" and "younger" among eruptive rocks. The "younger" eruptive rocks are essentially like the "older" in chemical composition, and their chief mineral constituents; and they differ, when at all, only in texture and some other points of as little importance—qualities that distinguish merely varieties, and which have proceeded from greater prevalence in these later times of sub-aerial eruptions.

6. Since "plagioclase" is not the name of a mineral species—several minerals of widely different compositions being embraced under it—it is a confounding of differences and resemblances to speak of it as a constituent of a rock. And since it now includes, through the defining of the feldspar microcline, a large part of potash feldspar, which had been supposed to be orthoclase, it has become almost synonymous with the term feldspar. The "simplicity" its adoption has been supposed to give to lithological system would be greater if "feldspar" were substituted, and with its present range of constitution, the evil would be hardly less.

7. Rocks differing mineralogically, and not chemically, like related hornblendic and augitic rocks (the minerals hornblende and augite being dimorphous) are rightly made distinct rocks, since the difference has depended, to a large extent, on wide-reaching geological operations or conditions, and is, therefore, of great geological significance.

8. Since quartz is the most widely distributed and therefore the least distinctive of the minerals of rocks, it may rightly be regarded as of subordinate importance in the distinguishing of rocks, and hence not only such names as *dioryte* and *quartz-dioryte, trachyte*, and *quartz-trachyte*, &c., are acceptable, but also *syenyte* and *quartz-syenyte*.

9. Biotite being closely like muscovite in composition, and not less common than it in granites, gneisses and mica schists, and being, moreover, unlike the mineral hornblende in chemical constitution and formula, the rocks in which biotite is a chief constituent cannot rightly be put in the same group with hornblende rocks; or those in which hornblende is a chief constituent in a group of mica-bearing rocks. Consequently the name "mica-dioryte," for a rock containing no hornblende, and the name "hornblende-granite" for a rock containing no mica but hornblende instead, imply alike false relations.

The discussion suggests the following additional remark:

The incapabilities of the microscope and polariscope have favoured the use of the term "plagioclase," and have led some investigators to overlook or slight distinctions in chemical constitution. Lithology is to receive hereafter its greatest advances through chemical analysis; for chemistry alone can clear away the doubts the microscope leaves, and so give that completeness to the Science of Rocks which geology requires for right and comprehensive conclusions.

Moreover the researches made in the laboratory, to be of real geological value should be, if possible, supplemented by investigations in the field as to transitions among the rocks, and as to other kinds of relations. This field work has often been well done, but not so by all lithological investigators.

The principles presented lead to the following sub-divisions in an arrangement of crystalline rocks, exclusive of the Calcareous and Quartzose kinds. Since leucite is a potash-alumina silicate, like orthoclase and microcline (it affording twenty per cent. or more of potash), it is here referred to the same group with the potash feldspars, and nephelite, sodalite and the saussurites being eminently soda-bearing species, they are included with the soda-lime feldspars (anorthite to albite.) This reference for lithological purposes of these minerals is sustained by their resemblance to the feldspars in constituents, and also in the quantivalent ratios between the alkalies, alumina and silica, this ratio being in leucite 1 3 8, as in andesite, and in sodalite and nephelite 1 3 4, as in anorthite. The term *potash-feldspar*, as used in the headings below, is hence to be understood as covering orthoclase, microcline and leucite; and *soda-lime feldspar*, as including the triclinic feldspars from anorthite to albite, and also nephelite, sodalite and saussurites.

The arrangement is as follows:—In the first series, the rocks graduate into kinds which are all feldspar, and into others that are all mica, and yet the amount of potash present is approximately the same.

I. *The Mica and Potash Feldspar Series*: including Granite, Granulyte, Gneiss, Protogine, Mica schist, &c., Felsyte, Trachyte, &c., and the Leucite rock of Wyoming.

II. *The Mica and Soda-Lime Feldspar Series*: including Kersantite, Kinzigite, and the Nephelitic kinds, Miascyte, Ditroyt, Phonolyte, &c. (These nephelitic kinds belong almost as well in the preceding series.)

III. *The Hornblende and Potash-Feldspar Series*: including Syenyte (with Quartz-syenyte), Syenyte-gneiss, Hornblende schist, Amphibolyte, Unakyte (this last containing epidote in place of hornblende), and the Nephelitic species Zircon-Syenyte, Foyayte.

IV. *The Hornblende and Soda-Lime Feldspar Series*: including Dioryte (with Propylyte), Andesyte, Labradioryte (or Labrador-dioryte), etc., and the saussurite rock, Euphotide.

V. *The Pyroxene and Potash Feldspar Series*: including Amphigenyte.

VI. *The Pyroxene and Soda-Lime Feldspar Series*: including Augite, Andesyte, Noryte (Hyperstheuyte and Gabbro in part), Hypersthenyte (containing true Hypersthene), Doleryte (comprising Basalt and Diabase), Nephelinyte, etc.

VII. *Pyroxene, Garnet, Epidote and Chrysolite Rocks, containing little or no Feldspar*: including Pyroxenyte, Lherzolyte, Garnetyte (Garnet rock), Eclogyte, Epidosyte, Chrysolyte or Dunyte (Chrysolite rock), &c.

VIII. *Hydrous Magnesian and Aluminous Rocks, containing little or no Feldspar*: including Chlorite schist, Talcose schist, Serpentine, Ophiolyte, Pyrophyllite schist, &c.—*Silliman's Journal*, December, 1878.

American Surveys.—In compliance with an order of the American Senate a Committee of the National Academy of Sciences has recently submitted to the President of the Senate its report upon the scientific surveys of the territories of the United States, and on the best methods of conducting all surveys of a scientific character under the War or Interior Department, and the surveys of the Land Office. The surveys particularly referred to in this report, are the Geographical surveys west of the one hundredth meridian under the War Department, the United States Geographical and Geological Surveys of the Territories, and of the Rocky Mountain region, under the Interior Department, the system of Land surveys under the supervision of the Land Office, and the coast and Geodetic surveys, one of the most important works now in progress in the interior. The objects of these surveys are: 1. An accurate geodetic survey; 2. A general and geographical reconnaissance; 3. Land parcelling surveys; and 4. The economic classification and valuation of the public domain. To these should be added the gradual completion of a general accurate topographical map of the United States, and all may be included under two distinct and separate heads, namely, Surveys of Mensuration, and Surveys of Geology and economic resources of the soil.

The report first considers the operations of the existing surveys of mensuration, which are now in progress under five different and independent organisations, and between which there is no co-ordination, the results of their work showing many contradictions, and moreover involving unnecessary expenditure. These five surveys are the coast and geodetic survey; the geographical surveys west of the one-hundredth meridian; the two topographical surveys under the Interior Department; and the Land Survey; but, as it is evident that both land parcelling and topographical surveys, to be sufficiently exact, must be placed upon a single rigid geodetic foundation, the report considers that these should be united into one comprehensive system, and recommends the coast and geodetic survey as best prepared to execute the entire mensuration required. It would therefore transfer that survey from the Treasury Department to the Department of the Interior, retaining its original field of operations, and giving it also the entire mensuration of the public domain under the name of the United States Coast and Interior Survey. This organisation would then embrace, in addition to its former work, a geodetic survey of the whole public domain, a topographical survey comprising detailed topographical work and rapid reconnaissance, and land-parcelling surveys.

As, however, this survey would not be called upon to notice the geological structure, natural resources and products of the territories surveyed the report recommends that an independent organisation should be established under the Department of the Interior, to be known as the United States Geological Survey, and to be charged only with the study of the geological structure and economic resources of the public domains.

With the inauguration of these two surveys the report recommends the

discontinuance of the present War Department surveys west of the one-hundredth meridian; of the geographical and geological surveys now in progress under the Department of the Interior; and of the land surveys under the Land Office.

These changes will bring within the Department of the Interior three distinct organisations—the Coast and Interior Survey; the United States Geological Survey; and the Land Office; and with this division the report considers that a perfect co-operation between the three branches should be secured, the work of each department being immediately available to the others. Each of the three organisations will make an annual report of its operations to the Secretary of the Interior, but besides this annual report the Coast and Interior Survey will publish its geodetic results, geographical, topographical, and cadastral maps, coast charts, &c., while the publications of the Geological Survey will include geological and economic maps, and reports upon general and economic geology, with the necessarily connected palæontology, and it is recommended that if the collections made by these departments are no longer required for the investigations in progress they should be transferred to the National Museum.

The report also recommends that of the publications of the Coast and Interior and the Geological surveys, besides the copies which may be ordered by Congress for its own distribution, three thousand copies be printed for scientific exchanges, and for sale at the price of publication — advice which it would be gratifying to see followed in some of our own scientific departments.

MINERALOGY.

Manganosite.—This curious mineral, first described by Blomstrand, of Lund, has recently been subjected to a closer examination by Klien. It occurs in dark coloured irregular grains enclosed in granular calcite; and, according to Blomstrand, they have a deep emerald-green hue, while by transmitted light they appear to have a ruby-red colour. The new species is of interest from its consisting of manganese protoxide; the occurrence in nature of so unstable a compound is remarkable. A freshly-fractured surface after exposure to the air for a few weeks becomes covered with a brown layer of oxide. Klien states that the mineral is cubic, and exhibits a fine dark green colour both by reflected and by transmitted light: and he has arrived at the conclusion that the red colour observed by Blomstrand was an effect of oxidation. The granules of manganosite, sometimes 1 cm. in diameter, are imperfectly formed octahedra. The forms produced by etching the crystals are four-sided pyramids with quadratic base.—*Jahrbuch für Mineralogie,* 1878, 750.

Iodobromite.—The "Schöne Aussicht" mine at Dernbach, near Montabaur, in the province of Nassau, which during the last few years has yielded fine specimens of beudantite and crystallised scorodite, has again attracted the attention of mineralogists from the fact that Von Lasaulx has recently found there a mineral which is not only curious as being the first compound of silver met with in that locality, but as new to science, and of peculiar interest

because it forms the first instance of the occurrence of this metal in nature in combination with the hyaloid elements: chlorine, bromine, and iodine. The composition of iodobromite, as he has termed it, is:

	Found.	Calculated.
Silver	59·96	60·88
Iodine	15·05	14·15
Bromine	17·30	17·18
Chlorine	7·09	7·79
	99·40	100·03

In the third column of the above table are given the percentage numbers corresponding with the formula 2Ag (Cl Br) + Ag I, which appears to be that of the new mineral. Iodobromite occurs in small regular octahedra of a yellow colour, some of them inclining more to the greenish hue of olivine. The crystals have a close resemblance to those of the bromyrite of San Onofre, near Zacatecas, Chañarcilla, and Hüelgot; they are malleable and sectile. None of the specimens of embolite (silver chloro-bromide) hitherto examined contain iodine. The iodides of sodium, zinc, &c., crystallise in forms belonging to the cubic system, and the fact of their being isomorphous with the corresponding chlorides and bromides of these metals points to the probability of the existence in nature of a silver iodide crystallised in the regular system. The silver iodide, as yet met with, has been found in hexagonal crystals closely according in their forms with crystals of greenockite. O. Lehmann has recently prepared (*Zeitschrift für Krystall.* 1877. I. 492) the iodide artificially in crystals which are regular. Von Lasaulx's discovery is of interest in its bearing on the isodimorphism of this group of salts.—*Jahrbuch für Minerologie*, 1878, 649.

Occurrence of Liquid Carbonic Acid in Syenite.—In his "Geological Report of New Hampshire" Howes describes the occurrence of liquid carbonic acid in the microscopic cavities existing in sections of the New Hampshire rocks. Although the number of sections examined was not large, the cavities were never met with in any of the granitic rocks except in a syenite from Columbia, and here they were found in the greatest abundance, and under circumstances which render their occurrence remarkable. The syenite referred to is white, spotted with black; macroscopically orthoclase and hornblende alone were recognisable. In thin sections, however, plagioclase, biotite, quartz, and apatite were seen, and, moreover, calcite, a mineral rarely occurring in granitic rocks. The quartz is present in small amount only, occupying angular interstices between the other ingredients; but each grain is filled with cavities which are quite large, and many of these contain liquid carbonic acid. Its presence in connection with calcite may indicate that calcium carbonate was a constituent of the sedimentary material of which this rock was formed, and that at the temperature at which crystallisation took place a reaction between the silicic acid and the carbonate resulted in the liberation of carbonic acid.—*Amer. Journ. Sc.* 1878, xvi. 326.

PHYSICS.

Determination of the Temperature of Incandescent Bodies by the Spectroscope.—M. Crova contributes a paper to the *Comptes Rendus* on this subject. It follows from the researches of Draper and Becquerel that when the temperature of an incandescent solid increases continuously, the spectrum lengthens towards the violet end. The temperature of the luminous source can, therefore, be measured (1) by the wave-length of the radiation which limits the spectrum towards the violet; (2) by the position of the thermal maximum of the spectrum which approaches nearer to the violet in proportion as the emission-temperature becomes higher; (3) by means of the ratio of the luminous intensity of a determinate radiation λ taken in the spectrum of the source to the intensity of the same radiation in the spectrum of a source of known temperature, compared with the ratio of the luminous intensities of another radiation λ' in the same two spectra. The last determinations can be easily effected by means of a spectro-photometer.

M. Crova has made numerous determinations of the thermal curves of the solar spectrum by means of a linear thermo-electric pile and a very sensitive galvanometer. These curves were rendered comparable with one another by bringing them to the scale of wave-lengths, and reducing, by means of the dispersion curve of the prism, the intensities to those which would correspond to the case of the normal spectrum of constant dispersion. With these he compares the spectrum of the electric light, the lime light, and the ordinary moderator lamp, always representing by 1000 the intensity corresponding to the wave-length 676. He states that, the intensity being the same in the red for the four spectra, the weakening towards the violet varies with each source according to a certain function of the temperature in the following order of increase:—Moderator, stearine candle, gas, lime light, electric light, and solar light.

The Experimental Determination of Magnetic Moments in Absolute Measure is the subject of the essay to which the Cleland gold medal was awarded. Beginning with a notice of Gauss's experiments on the intensity of the earth's magnetism, it states that no experiments have been published to determine the magnetic moments of steel magnets of different temper and tempered by different methods, giving information as to the permanence of their magnetism after a considerable time.

A reflecting magnetometer was used, consisting of a small mirror 1 centim. in diameter, carrying cemented to its back four small needles about ·8 centim. long, and suspended by a single silk fibre. Two arms of wood rotate round this, their upper sides level with the centre of the mirror, and grooved with a V-shaped depression in which the magnet to be tested could be laid. It could thus be made to form any angle with the magnetic meridian, and the apparatus could be used either on the method of sines or of tangents. The image of a fine wire was brought to a focus on a scale of half millimetres placed at a distance of a metre from the plane of the mirror. A large number of cylindrical steel bars were cut from one piece, and carefully filed to a uniform length of 5 centim. About sixty were raised to bright red heat, and plunged into water of 15° C. They were then made up into parcels of five and placed in a vessel containing oil. These parcels were removed at

successively increasing temperatures from 100° up to 310°. The heated oil was used also to temper a number of parcels by plunging them at a bright red heat into the oil at various temperatures.

All the bars were then magnetised by the current from ten Tray Daniells passing through a coil the same length as the bars, containing four layers of forty turns each, or 160 turns in all. The magnetising force was calculated at 377.

The value of the horizontal component of the earth's magnetic force at the place was computed by observing the period of oscillation of five separate magnets in reversed positions. The mean result, without correction for induction, was ·15390.

The magnets originally named were then magnetised a second time by a double battery and a coil of ten layers and seventy turns, giving a magnetising force of 1100. To show the relative effects of different magnetising forces on bars tempered "glass-hard" and "blue," two bars were brought, one to each of these tempers, and then magnetised, first with very small magnetising force, increased by measured amounts. The results are given in two compared curves, of which abscissæ are proportional to magnetising force, and ordinates to magnetic moments. The blue magnet is seen to rise more rapidly and to a higher point of saturation, though from 300 to 1,000 of abscissæ the two run near together and all but parallel, the blue slightly above the "glass-hard."

Magnets made of steel, suddenly cooled in cold water, were scarcely so strong as those which had afterwards been heated in oil up to 310° C., and allowed to cool slowly. By a second and stronger magnetisation, this difference was much diminished, probably from the softer steel being more easily raised to saturation. Bars cooled in cold oil had small magnetic moment; but this factor increased as the oil was raised to 150° C. It then amounted to 60 to 80 per gramme weight.

Homogeneous iron, or "mild steel," was also experimented on. In a "glass-hard" condition its magnetic moment was only 20·22, and at a blue temper little more than half this.

As regards permanence of the magnetism, it was little changed by nine months' undisturbed quiescence. The hard magnets lost about 2 per cent. of their moment when allowed to fall three times, with true north pole, down from a height of 70 centim. on a hard paving-stone. Blue magnets lost 10 per cent. After nine months the hard lost 0·5, and the blue 2·8, by the same treatment. The essay concludes with a series of tables embodying the above facts in a numerical form.

Binaural Audition.—The principal conclusions which Professor S. P. Thompson comes to on this subject are:—

(1.) There is interference in the perception of sound; for two simple tones capable of interfering are still heard to interfere when conducted separately to the two ears.

(2.) When two simple tones in unison reach the ears in opposite phases, the sound is localised at the back of the head.

(3.) The localisation of this acoustic "image" is independent of the pitch of the sounds.

(4.) When the difference of phase is partial, the sensation is localised, partly in the ears, and partly at the back of the head.

(5.) When two simple tones are led singly to the ears no differential tone is heard. There is some evidence that summational tones are heard.

(6.) In binaural audition dissonances are excessively disagreeable, and consonances harsh.

The Stability of Cleopatra's Needle.—A curious controversy has arisen in the columns of the "Times," and other papers, on this subject. The idea of any real instability no doubt arose from the unusual form of the monument, and the common error in estimating its dimensions. It seems the section is nowhere less in diameter than five feet; and, that being the case, it has been computed that it is competent to stand a wind pressure of 80 to 90 lbs. per square foot. It is said, however, that on January 30, 1868, at the Liverpool Observatory, the anemometer, which registers up to 60 lbs., was driven far beyond its limit, and that the pressure registered could not have been less than from 70 to 80 lbs. on the square foot. It is stated by the authorities that the maximum wind pressure in this country does not exceed 55 lbs. on the square foot. Mr. Dixon illustrated the subject by comparing the alleged pressure to the weight on the floor of a crowded room, which can attain from 80 lbs. to 120 lbs.; the latter with labourers of large stature packed as closely as possible. Thus, he remarked, as the windows certainly have to bear an equal strain with the walls, would anyone dream of standing on a floor formed of glazed window sashes? This *reductio ad absurdum* was, at first sight, conclusive against the accuracy of the anemometer. But Professor Unwin points out that, taking a plate of glass 2 feet in diameter, $\frac{1}{8}$-inch thick, and loaded with 80 lbs. per square foot, we get the greatest stress as = 4270 lbs. per square inch. Now the tenacity of glass has been found to be from 4,200 to 6,000 lbs. per square inch. Hence it is really possible that a pane of 2 feet in diameter might sustain the supposed load, if uniformly distributed, without breaking.

Mr. Dixon further declares that 130 lbs. of wind pressure would not upset it. This estimate, however, seems to need modification. "While," says a contemporary, "if a pressure of 80 lbs. is reached, it is very questionable if the survivors among the inhabitants of the neighbourhood will find it *in situ* when they have time to go to look for it."

On the Illumination of Lines of Molecular pressure, and the Trajectory of Molecules.—Mr. William Crookes read an important paper before the Royal Society on December 5 upon the above subject.

He has examined the dark space which appears round the negative pole of an ordinary vacuum tube, when the spark from an induction-coil is passed through it. The following are some of the propositions he arrives at:—

1. Setting up intense molecular vibration in a disc of metal by electrical means excites molecular disturbance which affects the disc and the surrounding gas. With a dense gas the disturbance extends only a short distance from the metal; but as rarefaction continues, the layer of molecular disturbance increases in thickness. In air at a pressure of ·078 millimetre this disturbance extends for at least 8 millimetres from the surface of the disc, forming an oblate spheroid around it.

2. The diameter of this dark space varies with the exhaustion; with the kind of gas in which it is produced; with the temperature of the negative pole; and, in a slight degree, with the intensity of the spark. For equal degrees of exhaustion it is greatest in hydrogen, and least in carbonic acid.

3. The shape and size of this dark space do not vary with the distance separating the poles, nor, except slightly, with increase of battery power; nor with intensity of spark.

He has devised many experiments to ascertain if this visible layer of molecular disturbance is identical with the invisible layer of molecular pressure, with the investigation of which he has for some years been occupied.

The Electrical Radiometer is made with aluminium-vanes coated with a film of mica. The fly is supported by a hard steel cup, and the needle point is connected with a platinum terminal sealed into the glass. At the top of the ball another terminal is sealed in. The fly therefore can be made the negative pole of an induction coil. When thus connected, a halo of velvety violet light forms on the metallic sides of the vanes, a dark space separating the violet halo from the metal. At the pressure of half a millim. the dark space extends to the glass, and positive rotation commences.

On continuing exhaustion the dark space further widens out, and appears to flatten itself against the glass, rotation becoming very rapid.

With an aluminium cup the conveyance of these lines of force to a focus on the concave side was observed. At very high exhaustions the dark space fills the tube, and at length the tube becomes beautifully illuminated by greenish yellow phosphorescent light. In an apparatus constructed for observing the position of the focus it was found that this is at the centre of curvature, the molecules being projected in a direction normal to the surface of the pole.

The spectrum of the green light is continuous, while that seen at lower exhaustions is characteristic of the residual gas. It is the same whether the residuum be nitrogen, hydrogen, or carbonic acid. It commences at different exhaustions in different gases.

The rays exciting this phosphorescence radiate in straight lines from the negative pole, casting strongly defined shadows of objects in their path. The ordinary luminousness of vacuum tubes will follow any number of curves and angles. From an examination of these shadows and other experiments he advances the theory that the induction-spark actually illuminates the lines of molecular pressure caused by electrical excitement of the negative pole.

The thickness of a dark space is a measure of the mean length of the path between successive collisions of the molecules. The extra velocity with which the molecules rebound from the excited negative pole keeps back the more slowly moving molecules which are advancing towards that pole. The conflict occurs at the boundary of the dark space where the luminous margin bears witness to the energy of the collisions.

When the exhaustion is sufficiently high, the rebounding molecules spend their force on the sides of the vessel, and the production of light is the consequence of this sudden arrest of velocity. The light actually proceeds from the glass. The shadows are not optical but molecular, revealed by the luminous effect. Experiments are given to show that an actual material blow is given by the molecules. The stream is very sensitive to magnetic influence, the action of the magnet being to twist their trajectory round, in a direction at an angle to their free path, the twist being that of the current

passing round the magnet. Great heat is evolved when the concentrated focus of rays from a nearly hemispherical aluminium cup is deflected sideways to the walls of the glass tube by a magnet. It may even be raised to the melting-point of platinum.

Mr. Crookes speculates on the "ultra-gaseous" state of matter, in which, under great rarefaction, the free path of a molecule is made so long that the hits in a given time may be disregarded in comparison to the misses, the properties of "gaseity" are reduced to a minimum, and the matter exalted to a state in which very decided, but hitherto masked, properties come into play. This reveals a new world, wherein matter exists in a fourth state, where the corpuscular theory of light holds good, and where light does not always move in a straight line; but which we must be content to observe and experiment on from the outside.

Some Recent Acoustical Researches.—The harmonic overtones which accompany a musical note are a well-known phenomenon, and their nature has been made pretty clear. There is another phenomenon presenting a certain analogy to this. It has lately been studied by a German physicist, Herr Auerbach, who applies to the notes generated the corresponding name of undertones. These undertones may be had by striking a tuning-fork vigorously, then placing its stem very lightly on a sounding-board. One hears the lower octave of the fundamental note of the tuning-fork. With suitable materials, Herr Auerbach also obtains the lower fifth of the lower octave, and the lower fourth of this tone—that is, the double octave of the fork's tone; in fact, these resonance tones form a series of harmonic undertones. The phenomenon appears to depend essentially on the strength of the vibrations and the imperfect elasticity of the resonance-surface of the plate. Herr Auerbach has tried a variety of substances for undertones with tuning-forks. He finds that some, indeed most, substances give these tones; that some give only a noise, as soon as the vibrations are moderately strong; and some always give the tone of the fork, no matter how strongly this is sounded. Another German observer, Herr von Strouhal, has recently given some attention to a kind of tones not much studied hitherto—viz., those which arise when a rod is quickly swung through the air, or when currents of air impinge on stretched wires or sharp edges, &c. For pureness of tone, the swung rod must have all its parts moved with the same velocity, and it must be cylindrical. Herr Strouhal made an apparatus consisting of a vertical wooden column with two horizontal arms, between which the bodies to be forced through the air (mostly wires) were fixed, and he rotated the frame in its upright position at various speeds. Thus he got notes which rose in intensity and pitch with the speed. He found that the pitch of the "friction tone" (as he calls it) is independent of the tension of the wire, likewise of its length. But the length of the wire has a marked influence on the intensity of the tone. The longer the wire, the stronger (*cæteris paribus*) the tone. Further, the substance of the body is a matter of indifference; but the height of the tone is directly proportional to the velocity of motion, and inversely so to the diameter of the wire. The author finds, moreover, that there is a way of making the "friction tone" produce the wire's own tone—viz., when it is brought up to the same pitch with this (the wire being preferably thin and elastic), and similarly, by raising the pitch gradually

higher, the succession of overtones of the wire are generated. The distinct character of the general phenomenon above indicated appears from the fact, among others, that with rising temperature the friction tone becomes lower. The true nature of these tones is at present somewhat obscure. Herr Strouhal offers, with reserve, an interpretation of the facts, for which, however, we must refer to his original paper in the "Annalen der Physik und Chemie."

The Nature of the Elements.—Mr. J. Norman Lockyer read an elaborate paper on this subject before the Royal Society on Dec. 12. He discussed the evidence obtained from spectroscopic observation of the sun and stars, leading to the conclusion that the so-called elements of the chemist are in reality compound bodies. The method by which Mr. Lockyer proceeds was explained in the last number, while reviewing his recent work "Studies in Spectrum Analysis." By turning the slit of the spectroscope through 90°, and throwing an image of the luminous body on it by means of a lens, he is enabled to study the various regions of the heated vapour, and to establish the fact that all the lines in the spectrum of the substance volatilised do not extend to equal distances from the poles. It is found that the lines furnished by a particular substance vary not only in length and number, but also in brightness and thickness according to the relative amount present. About four years ago Mr. Lockyer commenced a map of the spectrum of the sun on this principle, with a view of ascertaining more definitely than has hitherto been possible which elements are present in it. A collateral result of this important work is to show that the hypothesis that identical lines in different spectra are due to impurities is not sufficient; for he finds short-line coincidences between the spectra of many metals in which the freedom from mutual impurity has been demonstrated by the absence of the longest lines. There are, moreover, many facts which point to another hypothesis, namely that the elements themselves, or at all events some of them, are compound bodies. Thus it seems that the hotter a star the simpler its spectrum, for the brightest, such as Sirius, furnish only very thick hydrogen lines and a few very thin metallic lines, characteristic of elements of low atomic weight; while the cooler stars, such as our sun, are shown by their spectra to contain a much larger number of metallic elements than stars such as Sirius, but no non-metallic elements. The coolest stars furnish fluted band spectra characteristic of compounds of metallic with non-metallic elements. The facts are easily explained if it be supposed that as the temperature increases the compounds are first broken up into their constituent "elements" and that these "elements" then undergo dissociation or decomposition into constituents of lower atomic weight. If A contains B as an impurity, or as a constituent, in both cases A will have a spectrum of its own. B, however, if present as an impurity, will merely add its lines according to the amount present, whereas if a constituent of A it will add its lines according to the extent to which A is decomposed and B set at liberty. So as the temperature increases the spectrum of A will fade if A be a compound body, whereas it will not fade if A be a true element. Moreover if A be a compound body, the longest lines at one temperature will not be the longest at another.

From this point of view, the spectra of calcium, iron, hydrogen, and lithium are observed at different temperatures. It is shown that precisely

PHYSIOLOGY.

On the Effects of Varnishing the Skin in the Lower Animals.—At least since the time of that Pope of Rome who varnished an unfortunate urchin into the semblance of a golden child, the fatal effect of coating the skin of animals with impermeable varnish has been well known. While a certain portion of the skin may be thus coated without producing serious derangement of the organisation, when the proportion reaches to about one-sixth, death can only be avoided by a considerable increase of the temperature in which the animal is kept. It was supposed that these phenomena were due to the suppression of the functions of the skin, which caused a retention of excrementitious matter in the system, giving rise to a form of toxæmia. Another explanation, however, of the fatal results produced by body-varnishing was ably advocated in 1868 by Laschkewitch, who attributed death to the rapid loss of heat experienced by varnished animals, and this view appears until recently to have been very generally received. Latterly, however, the older explanation has been supported by Lange and Sakolow, which has led M. Lomikowsky to reinvestigate the subject, particularly with the object of ascertaining the cause of the rapid decrease of temperature in varnished animals. With the help of the thermomultiplier, he has been able to prove that the radiation is much greater from varnished than from unvarnished animals, the difference being quite sufficient to account for the loss of heat and the fall of temperature, while the symptoms observed during life and the changes observed in the viscera after death are fully accounted for by the cooling, being in fact identical with those found in animals killed by exposure to cold. With universal varnishing, as with extreme cold, death occurs rapidly, while a more moderate cold or a partial varnishing excite inflammatory changes in the internal organs, more particularly in the kidneys, and cessation of life indirectly ensues as a consequence of uræmia.

ZOOLOGY.

Reproduction of Hydra.—M. Korotneff has arrived at very different conclusions from those of Kleinenberg upon this subject. According to the latter the reproductive cells occur below the ectoderm and form a mass which serves for the production of both ova and spermatozoids. The process described by him is as follows: one of the cells of this mass increases considerably and swallows up the surrounding cells, or, in other words, feeds upon them. The nucleus then becomes transformed into a germinal vesicle and finally the cell comes to represent the ovum of the *Hydra* which is thus in its origin a unicellular and ectodermal formation. The granulations of the ovum serve to produce the larger elements described by Kleinenberg under the name of *pseudo-cells.* The blastoderm, according to Kleinenberg, is formed immediately after the conclusion of segmentation, and consists of a layer of cells forming the whole envelope of the ovum. It is regarded by him as an embryonic epithelium, taking no part in the ultimate formation of the *Hydra,* but to be rejected at a certain period of development. Hence the adult *Hydra* is destitute of epithelium.

The author, like Kleinenberg, has observed an agglomeration of cells of ectodermic origin, but regards them merely as embryonic cells, serving to reproduce different ectodermic elements. One of these cells increases, and its nucleus is converted into a germinal vesicle; while at the same time the peripheral elements of the mass separate, forming a row of cells with very small refractive granules, and the central cells unite with each other and with the enlarged cell, forming a common plasmodium sprinkled with numerous nuclei. The germinal vesicle is degraded and disappears entirely; the nuclei of the central cells increase a little in volume and degenerate into fatty bodies, and some of them divide. These are probably Kleinenberg's pseudo-cells. The peripheral elements of the mass sprinkled with chitinous granules form the envelope of the ovum. M. Korotneff concludes that Kleinenberg mistook these peripheral elements for a blastoderm, and the mass of central cells for the result of a true segmentation.—*Comptes Rendus*, September 9, 1878.

The Buzzing of Insects.—M. Jousset de Bellesme objects to the theory of the cause of buzzing in insects proposed by M. Perez as noticed in our last number. He remarks that all insects in which the wings make more than eighty vibrations per second emit a perceptible sound which is suppressed by the removal of the wings. The diptera and hymenoptera emit two sounds—that just mentioned, which is deep; and another sharper sound, generally the octave of the former. This is the essential characteristic of buzzing. When the wings are cut off a *Volucella* or humble-bee, the deep sound is abolished, but the sharper one persists. The former is therefore produced by the wing, while the latter is independent of it.

M. de Bellesme agrees with M. Perez that this sound is not connected with the passage of air through the thoracic stigmata, and he seeks its cause in the mechanism by which the wing is set in motion. He says that in buzzing insects the muscles of flight are not inserted directly upon the wing, but upon the pieces of the thorax which carry it, and that it is the movement of these that causes that of the wing. The thorax, therefore, undergoes continual changes of form under the contraction of these motor muscles. In repose a section of this region represents a vertically elongated ellipse, which the action of the muscles converts into a horizontally elongated ellipse. The entire thorax, therefore, vibrates successively in the direction of its two diameters; and, as the muscles are very powerful, the vibratory movement is very intense, and the thorax constitutes a vibrating body which acts directly upon the surrounding air. The thoracic sound is higher after the wings are cut away. This is because during flight the resistance of air acting upon the wings diminishes the velocity of contraction of the muscles. By attaching a style to the upper wall of the thorax after the removal of the wings the author was enabled to inscribe these vibrations, and obtained traces in which the number of vibrations corresponded exactly to the sound produced. —*Comptes Rendus*, October 7, 1878.

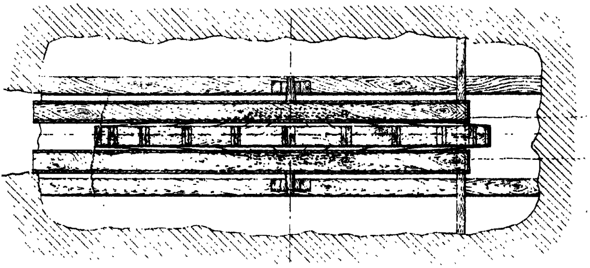
The Poison Glands of the Centipedes.—It has long been known that the Chilopod Myriopoda, commonly known as Centipedes, which are carnivorous in their habits, kill their prey by a poison injected at the first bite of their formidable nippers. The seat of the glands secreting the poisonous fluid was, however, unknown, the organs formerly supposed to secrete the venom being

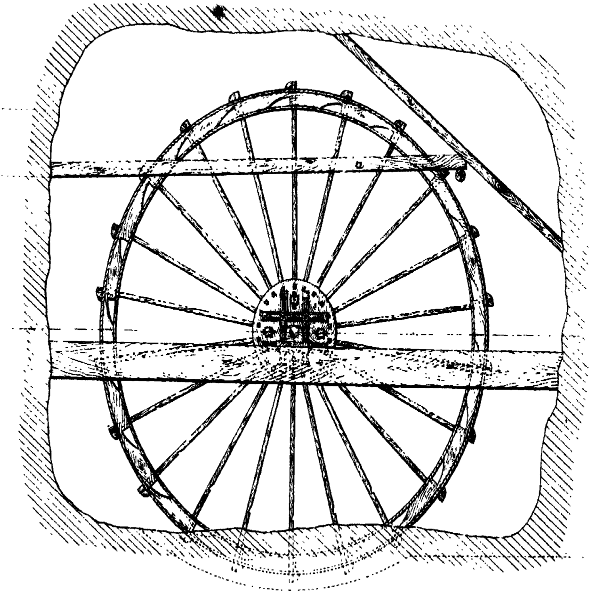
found to pour their secretion into the cavity of the mouth, and not into the nippers. Mr. M'Leod, during a residence in Java, took the opportunity of examining some of the large centipedes with which that island abounds, and especially *Scolopendra horrida*; and finding that, as above stated, the glands which might easily be taken for poison glands had nothing to do with the nippers, which, nevertheless, always exhibited a very distinct orifice at the tip, he was led to search for the glands in the interior of those organs themselves.

The process he adopted is one that has of late given admirable results in the investigation of the anatomy of many animals; namely, the preparation of sections of them in various directions after they had been immersed in melted paraffin, the subsequent hardening of which keeps all parts in their natural positions during the operation of cutting. By this means he detected the poison gland, which is situated partly in the actual biting portion of the nipper, and partly in the broad basal joint which supports the latter. The glandular apparatus consists of a chitinous duct leading to the orifice at the apex of the organ, and forming the axis of the gland. It is perforated in its course by a multitude of small apertures, each of which leads into a minute cylindrical tube terminating in a long secreting cell, the whole mass of these cells being arranged in a radiating fashion around the duct. The entire organ is surrounded by a membrane, and has the general form of a four-sided prism. Notwithstanding its comparatively small size, Mr. M'Leod has detected the same arrangement in *Lithobius forficatus* (the common European centipede).—*Bull. Acad. Roy. de Belgique*, tome xlv. 1878.

Sponge-borings in Marble.—Most naturalists are aware of the power possessed by certain sponges forming the genus *Cliona* of boring into the shells of mollusca and other hard bodies, but we are hardly prepared to hear of their making their way into so refractory a substance as statuary marble. Prof. Verrill, however, states (*Silliman's Journal*, November, 1878) that the Peabody Museum of Yale College has lately received some fragments of white Italian marble from a cargo wrecked off Long Island in 1871, and taken up this year, in which "the exposed portions of the slabs are thoroughly penetrated to the depth of one or two inches by the crooked and irregular borings or galleries of the sponge *Cliona sulphurea*, V.," and reduced "to a complete honeycomb readily crumbling in the fingers. Beyond the borings the marble is perfectly sound and unaltered." Prof. Verrill remarks that the possession of such boring powers by this apparently insignificant sponge may have a practical bearing in the case of submarine constructions of limestone or similar materials.

PLAN.





SIDE ELEVATION.

ANCIENT ROMAN DRAINAGE-WHEEL.

THE SOURCES AND USES OF IRON PYRITES.

By J. ARTHUR PHILLIPS, F.G.S.

[PLATES III. & IV.]

THE process still generally employed for the manufacture of carbonate of soda from common salt was the discovery of the French Chemist Leblanc, and was first carried out, on a large scale, by him and his partners in France. Previous to the revolution of 1789 the only kind of soda commercially known was that obtained from various marine plants, the greater portion of the raw material having been imported from the coast of Spain and Portugal.

The wars which were at that time ravaging Europe naturally had the effect of putting a stop to this branch of industry, and although, in case of need, potash may replace soda in the manufacture of glass and soap, the emergency of the times rendered it necessary that the whole of the available potash should be converted into saltpetre for the preparation of gunpowder.

With a view to meeting this very serious difficulty, the Committee of Public Safety called, by special proclamation, upon all citizens to place in the hands of commissioners for the public benefit, and without regard to private interests, whatever plans or methods of preparing soda might be known to any of them.

In consequence of this demand numerous schemes were laid before the Commissioners, who eventually reported that the method proposed by M. Leblanc appeared to be that best adapted for the manufacture of soda upon an extensive scale. This process consists in first converting chloride of sodium into sulphate of soda by the addition of sulphuric acid, and the subsequent decomposition of sulphate of soda, at a high temperature, by a mixture of limestone and dust coal.

In order to convert one ton of common salt into sulphate of

soda (salt cake), 16 cwt. of concentrated sulphuric acid (oil of vitriol) are required, and it therefore follows that with an active development of this new industry the demand for sulphuric acid and for the materials requisite for its production rapidly increased. In the preparation of this acid upon a large scale, sulphurous acid, obtained by burning sulphur or pyrites, is converted into sulphuric acid by means of a powerfully oxidising agent. The substance now universally employed for this purpose is nitric acid, although the greater portion of the oxygen utilised is not derived directly from the acid, but indirectly from the air; the result of complex chemical changes which take place in extensive leaden chambers supplied with watery vapour by means of steam jets.

Previous to 1838, sulphur was the material almost universally made use of in the production of oil of vitriol, but in that year the King of Naples having granted a monopoly of Sicilian sulphur to a French firm at Marseilles, it resulted in the gradual introduction of iron pyrites as a substitute for brimstone in the manufacture of sulphuric acid.

From that date to the present the consumption of this mineral has gone on steadily increasing; the mines of Cornwall and those of Wicklow in Ireland having been, during many years, the chief sources of supply. A certain amount was also obtained from Norway.

About the year 1853 small quantities of pyrites containing a little copper found their way into this country from mines worked by a French company in the South of Spain, but as their transit, on mule-back, to the shipping port was long, the supply was limited, and the results are believed to have been financially unsatisfactory.

A few years subsequent to this (1859), Mr. James Mason opened out the now celebrated mines of San Domingos in Portugal, and having connected it by railway with the river Guadiana, near the town of Pomaron, commenced an active competition with the pyrites from Cornwall, Wicklow, and Norway. The comparative freedom of this ore from arsenic, and the small proportion of gangue which it contains, caused it to be generally preferred to pyrites from other localities, so that the quantity imported into Great Britain in 1868 from this mine alone amounted to no less than 83,000 tons.

At this period the Tharsis Sulphur and Copper Company, who had now taken over the mines formerly worked by the French Company, already referred to, had not only commenced exporting pyrites from Spain, but had also erected various extensive works in this country for the extraction of copper, by a humid process, from the cinder, or residue, remaining in the kilns of sulphuric acid manufacturers after the removal of sulphur.

and oxidation of its associated iron. The Buitron Company, whose mines are situated in the same province of Huelva, also for a short time contributed a considerable amount of pyrites to this market, but the largest undertaking in connection with mining for this mineral is unquestionably that of the Rio Tinto Company, commenced in 1873.

The deposits belonging to this association are situated near a town of that name, 84 kilometres, or 52 miles, north of the port of Huelva, at the mouth of the river Odiel, with which they are connected by a railway. In this part of Spain the deposits of cupreous pyrites consist of a series of more or less continuous lenticular masses of ore, possessing a general direction a little north of east, and south of west, extending from Aznalcollar near Seville, in the east, for a distance of more than 70 miles westward, to the well-known mines of San Domingos, within the Portuguese frontier.

The substance of these deposits consists of an intimate and compact admixture of iron pyrites with a little copper pyrites through which strings of the latter mineral are sometimes observed to ramify; small veins of black sulphide of copper less frequently traverse the mass. Galena and blende are also present, as well as arsenical pyrites in small quantity; and in the ancient workings great quantities of blue and green vitriols are met with, as a product of oxidation of the ore by the action of air and water.

As already stated, these lodes may be regarded as enormous lenticular masses of cupreous pyrites, in which small strings of copper ores containing from 5 up to 40 per cent. of that metal are occasionally met with, but more particularly in the vicinity of the walls and in the neighbourhood of quartz veins. This fact was evidently known to the Romans, who entirely confined their operations to such rich ores, and neglected the general mass of the lodes which does not contain much above 2 per cent. of copper.

The prevailing rocks throughout the entire district are clay slates, which, from some imperfect fossils recently discovered in them, would appear to be of Silurian age. These slates are in places disturbed by dykes of diabase and quartz-porphyry, the latter rock frequently forming one of the walls of the metalliferous lode.

These deposits have, almost without exception, been wrought in remote antiquity, the workings having in some exceptional cases reached a depth of nearly 50 fathoms beneath the surface. The larger proportion of these ancient excavations are manifestly of Roman origin, although the occasional discovery of stone implements would appear to indicate that the ferruginous capping of the veins furnished a red pigment to the early in-

habitants of the country at a still more remote period. Among the objects of this description found in the overburden above the outcrop of the south lode at Rio Tinto was a slab of hæmatite about nine inches square and three in thickness, on the surface of which were two rows of regularly arranged depressions, each about two inches in diameter. These had evidently been made by the action of a small muller of coarse porphyry which was found alongside; doubtless, forming an arrangement by which a red pigment was readily obtained by mixing with a little water the material ground from the substance of the slab.

The Roman workings consist of numerous circular shafts, sometimes where necessary lined with stone, and seldom more than thirty inches in diameter; these are in connection with various tortuous galleries which invariably follow the direction of rich branches of ore. By becoming saturated with waters holding copper salts in solution, the woodwork of these mines has been wonderfully preserved, while its tissue is often more or less permeated by metallic copper resulting from the reduction of its sulphates by woody fibre. In this way timbers made use of for supporting the ground are sometimes in such good preservation as to retain marks made upon them sixteen centuries ago, and letters cut by Roman miners are almost as fresh as those carved by a school-boy of the present day.

The Roman method of drainage was partly by adits, of which several of great length are known to exist; but they also employed various mechanical means for the removal of water below the level of such outlets. A curious discovery of machinery of this class was made some years since in the mine of San Domingos where a number of wheels constructed entirely of wood, and each 16 feet in diameter, were found placed one above another in large cisterns or troughs. Through the kindness of Messrs. Mason and Barry I am enabled to give an illustration of one of these wheels from a drawing made upon the spot. Plate III. represents a plan and elevation of one of these remnants of early engineering, as placed in the mines.

This wheel is constructed entirely of wood, and closely resembles an ordinary water-wheel with the buckets reversed; only that as the internal and external rings are complete throughout, the water, when once taken up, can only escape by the openings shown in the sides. In this way water which has entered the buckets, while that portion of the periphery was passing through the well, on being raised to the height of the two troughs or launders *a*, flows into them through these openings in the sides of the wheel, and is conveyed by them into another trough at a slightly lower level. It is consequently evident that by the use of a number of such wheels, one placed higher than another, and all turned at the same time by means of

their radiating arms, water could be raised from considerable depths. Ten of these wheels have been discovered at San Domingos; eight of them were 16ft. in diameter, and the other two 12ft. 6in.

The remains of another Roman contrivance for the drainage of water were discovered some years since in one of the Spanish mines near Seville. This arrangement consisted of a number of Archimedean screws which, one after another, raised the water from a series of wooden tanks lined with sheet lead. The whole of this apparatus, with the exception of the leaden lining of the cisterns, was composed of wood fastened with oaken pegs, and sometimes strengthened by ropes of esparto grass; the constructors thus evidently showing they were aware that iron was unfitted for this purpose in the presence of cupreous waters by which it is rapidly acted upon.

Earthenware lamps of Roman workmanship are constantly found in the old workings of the mines, while vessels and implements of copper or bronze are occasionally met with; less frequently human bones are exposed, which, by the action of copper salts upon their calcic phosphate, have assumed an appearance approaching that of turquoise. It may be mentioned also that some years since a bronze plate was found at the entrance of a crushed Roman gallery at Rio Tinto, which stated it had been begun during the reign of Cocceius Nerva, A.D. 96–98. This plate is now in the collection of the School of Mines at Madrid.

The Roman metallurgist smelted his ores in the immediate vicinity of the mines from which they were obtained, and the discovery of the foundations of blast-furnaces, as well as of fragments of earthen *tuyères*, renders it probable that a blast of some kind was used. This is confirmed by the form assumed by the cakes of slag, of which vast heaps are piled up in the neighbourhood of all the principal pyrites mines of Spain; these slag-heaps are usually situated above the level of the water-courses of the district, from which it may be inferred, either that the blast was obtained by manual labour, or that a furnace allied to the modern *pavo*, still used for smelting lead ores and slags in the neighbourhood of Carthagena, was employed.

The extent of the mining and metallurgical operations, anciently carried out in this portion of Southern Spain, will be readily understood when it is stated that the slag-heaps in close proximity to Rio Tinto cannot weigh less than a million and a half tons, and that there are large, although less extensive, deposits at Tharsis, Buitron, and various other localities. That, at least, a portion of the labour of these establishments was performed by slaves is abundantly evident from the repeated discovery of skeletons still retaining their chains. At a

distance of one hundred and fifty yards from the principal slag-heaps at Rio Tinto, the foundations of extensive buildings may be readily traced, and a little beyond them is a Roman cemetery in which thousands of interments must, at various times, have taken place. On a portion of this ground, over which are strewed the columns of a ruined temple, broken tombstones of ferruginous conglomerate are abundant; but the inscriptions, which were on metal plates, of which indications are still visible, have in every case been removed. In this part of the cemetery all the graves have been long ago opened and their contents removed, but wherever the ground is disturbed in the surrounding oak wood, which covers several acres, stone cists are found containing burnt bones, pottery, glass vessels, leaden plummets, links of iron chain, and pieces of litharge.

The presence of litharge in these tombs, which are of undoubtedly Roman age, with the occasional discovery of pigs of Roman lead, renders it more than probable that the then high price of gold and silver enabled the metallurgist of that day to extract with advantage the extremely small amount of these metals present in the pyrites of Rio Tinto. This was probably effected by liquation and the subsequent cupellation of the resulting lead.

Forgetting the difference in the value of metals then and now, overlooking the cheap labour of Roman times, and taking for granted that work done so long ago must of necessity have been done badly, the idea has presented itself to various amateur metallurgists that such slags might be re-smelted with advantage. The analysis of an average sample of these Roman slags, by Mr. G. W. H. Clement, formerly chemist to the Rio Tinto Co., is however sufficient not only to show the great skill of these ancient artificers, but also to demonstrate the utter futility of any attempt to re-treat their residues. The results obtained were as follows:—

Water	1·05
Silica	32·02
Alumina	6·85
Lime	2·23
Magnesia	·31
Ferrous oxide	50·02
Ferric oxide	4·48
Plumbic oxide	1·00
Cupric oxide	·18
Metallic iron	·45
Ferrous sulphide	1·35
Alkalies	·28
	100·22

The above analysis indicates that in every ton of slag there are about 3 lbs. of copper, which, if it were possible to recover

the whole, would be worth say 1*s.* 8*d.*; a sum far too small to cover the cost of any known method of treatment.

At the present time all the principal pyrites deposits are worked as large quarries or open cuttings from which a certain amount of overburden has to be removed, while the mineral is transported by locomotive power over railways connecting the mines with their respective shipping ports. The very extensive scale upon which they are now conducted will be gathered from the following figures.

At Tharsis, during the year 1877, no less than 371,230 cubic yards of overburden were removed and 435,876 tons of pyrites extracted; of this amount 249,299 tons were shipped for the use of alkali manufacturers, manure makers, &c., while 186,577 tons were retained for local treatment for copper. In addition to this 45,415 tons of ore were extracted and treated at Calañas, while the amount of copper precipitate exported amounted to 7,199 tons.

The total quantity of pyrites raised during 1877 from the Tharsis and Calañas mines was 481,920 tons, and the average number of work-people employed throughout the year 3,181, embracing a population of about 6,500 either resident on or dependent upon the mines.

The Rio Tinto mines, like the Tharsis, are worked *à ciel ouvert*, and during the year 1877, 773,366 cubic yards of overburden were removed as well as 771,751 tons of pyrites extracted; of this amount 251,360 tons were exported, and 520,391 tons retained for local treatment. During the same period copper precipitate representing 2,735 tons of metallic copper was exported, and at the close of the present year the annual production of metallic copper will probably not have fallen short of 6,500 tons.

At the San Domingos mines the total production of pyrites in 1877 was 341,000 tons, of which 163,000 tons were exported, while the copper precipitate shipped amounted to 3,050 tons; as in the case of the Rio Tinto works, the local production of copper during the current twelve months will be much larger than in 1877.

The largest deposits of pyrites are those of Rio Tinto, where three very wide and nearly parallel lodes are known to exist; of these, however, the more southerly only is at present worked. Hundreds of Roman shafts are scattered over the outcrop of the central and northern deposits, and it is believed that a very large proportion of the ores which have furnished the vast heaps of ancient slags accumulated in this vicinity were obtained from these lodes.

At San Domingos and Tharsis the mines were found by the present proprietors in the exact state in which they were left

by the Roman workmen, whereas at Rio Tinto they had been partially worked by the Spanish Government up to the time of their transfer to the English company. The south lode is, however, the only portion of the property which has been worked in modern times, and the portion which has been recently uncovered has to a considerable extent been honey-combed by Roman and Spanish workings as far down as the ninth floor. This has had the effect of, to some extent, bleeding the vein by the continual drainage of copper water which has for many years produced, by precipitation, about three-and-a-half tons of metallic copper weekly.

That portion of the vein which was selected by the late Mr. David Forbes F.R.S. for an open cutting is about 200 fathoms in length and is, in the widest part, about 47 fathoms in width; the outcrop of this deposit is 45 fathoms above the valley of the Rio Agrio, with which the workings communicate by a large drainage-tunnel in which a double line of rails has been laid down. The total yield of this portion of the lode to the level of the valley was, when first opened, calculated at about 11,000,000 tons.

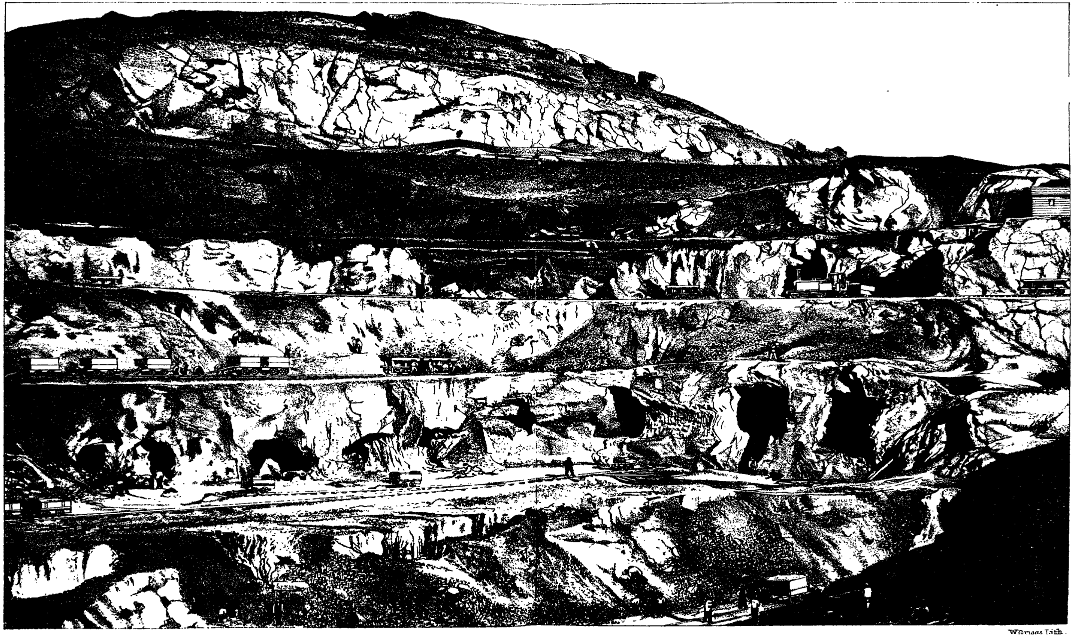
The open cutting is worked in stages, or steps, each connected by tunnels with a railway by which the richer ores, intended for exportation, are taken to the main line, by which they are sent to the port of shipment at Huelva; while the poorer ores, destined for local treatment, are taken to the calcination grounds. The total length of these local railways, which are of the same gauge as the main line and are worked by locomotive power, is 17 miles.

The illustration, Plate IV., from a photograph of a portion of the Rio Tinto cutting, looking north, shows some of the Roman and early Spanish workings which have been cut into during the progress of the work.

On arriving on the calcination grounds the ores are built into heaps, or *teleras*, of the form of a beehive, each containing from 100 to 500 tons; these are lighted at bottom, either by the help of brushwood or of a little coal, and the sulphur of the pyrites, taking fire, a slow combustion is continued during several months.

At the expiration of some eight or nine months the teleras have generally burnt out, and a large proportion of the copper has been converted into cupric sulphate, which is a salt soluble in water.

The ore is now removed to large tanks, each some 60 feet long, 16 feet in width, and 3 feet in depth, where it is lixiviated by successive additions of water which, after dissolving out the salts of copper, is run through an extensive labyrinth of tanks in which pig iron is regularly stacked in hollow piles. Here



W. Griggs Lith.

the sulphuric acid of the sulphate of copper transfers itself to the iron with formation of soluble ferrous sulphate, while the copper, in a metallic granular state, but contaminated with the carbon and some other impurities of the pig iron, is deposited. In order to collect this precipitated copper, the liquors are diverted in succession from the various tanks forming portions of the arrangement for precipitation, the liquid drawn off, and the iron removed from one end of the tank, any adhering copper being brushed off. The copper in the bottom of the tank is now collected, and the cleaned iron replaced with an addition of fresh pig; the operation being continued with the next stack in succession, until the whole of the pig iron has been cleaned and freshly stacked, and nearly the whole of the copper taken out. This precipitated copper, when washed, freed from fragments of iron, and calcined, contains about 75 per cent. of metallic copper; it is then bagged and forwarded to England to be refined and melted into ingots, as the high price of fuel in Spain renders it inexpedient to complete its metallurgical treatment in that country.

On account of the very limited rainfall which occurs in this portion of the Spanish peninsula, the supply of water requisite for these operations is exceedingly difficult to obtain, and it has consequently been found necessary to dam two large valleys by dykes, thus making reservoirs, of which one will be provided with powerful pumping machinery. The first of these tanks, which has for some time been in operation, is capable of containing 70,620,000 gallons of water, while the other, now in course of construction, will have a capacity of over 100,000,000 gallons.

All the engineering work connected with this vast undertaking has been skilfully designed and efficiently carried out by the resident manager, Mr. M. W. Carr, whose arrangements are already so far advanced that the production of copper from the extraction works alone already exceeds 150 tons per week.

The average number of work-people now employed upon the mines, railway, and calcination grounds of the Rio Tinto Company, may be taken at about 5,000, but upon the completion of works in connection with the water supply, this number will be reduced, while the output of copper will be largely increased.

The ores obtained from the different mines very closely resemble one another in composition, but, as already stated, the richer, "selected," ores only are exported for the use of the alkali manufacturer, the poorer varieties being retained for local treatment.

The following analysis, by Mr. F. Claudet, of pyrites from the San Domingos mine, may be taken as an average sample of good exported ore:—

Sulphur	49·00
Arsenic	·47
Iron	43·55
Copper	3·20
Zinc	·35
Cobalt	trace
Silver	trace
Lead	·93
Lime	·10
Insoluble residue	·63
Water	·70
Oxygen and loss	1·07
	100·00

When this ore is burnt for the production of sulphuric acid, the resulting cinder may be taken to have, approximately, the following composition:—

Sulphur	3·76
Arsenic	·25
Iron	58·25 = 83 °/ₒ Fe_2O_3
Copper	4·14
Zinc	·37
Cobalt	trace
Silver	trace
Lead	1·14
Lime	·25
Insoluble residue	1·06
Water	3·85
Oxygen and loss	26·93
	100·00

The amount of silver in burnt ore varies from 15 or 18 dwt. per ton in the San Domingos cinders, to 1oz. 15dwt. in that from Rio Tinto pyrites. A few grains of gold per ton are also contained in all Spanish and Portuguese ores.

In order to obtain the copper by the wet process of extraction, the burnt ore is first finely ground and sifted, and subsequently roasted with about 12 per cent. of common salt until, by the oxidation of the metallic sulphides, a portion of the salt is converted into sulphate of soda, while the copper becomes transformed into a soluble chloride. The copper salt is subsequently removed by repeated washings with hot water, and the copper precipitated in the metallic state by scrap iron.

After the removal of the copper by solution the residual "purple ore" or "blue billy" is thrown out of the washing vats, which are again filled with freshly roasted ore, and the operation proceeds as before. The purple ore so obtained contains 96 per cent. of peroxide of iron, equal to 67 per cent. of metallic iron, and as it contains no phosphorus, and only traces of sulphur, it is largely employed in the blast-furnace as a source of iron, as well as for the lining of puddling furnaces.

The silver contained in these ores was for some time lost, but by a process invented by Mr. Claudet, it is now, to a very large extent, recovered, and a portion of the gold is at the same time obtained.

Nearly the whole of the precious metals present in the burnt ores is contained in the first three washings from the roasted cinder, and, after ascertaining, by means of an assay, the proportion of silver present, a sufficient amount of a standardised solution of iodide of potassium is added. This causes the precipitation of the silver in the form of an insoluble iodide of that metal. The whole is then allowed to stand for forty-eight hours, in order to allow the precipitate to settle, and the supernatant copper liquor is afterwards run off to the tanks containing iron for precipitation.

The argentiferous precipitate, after having been duly washed, is decomposed by boiling with metallic zinc; by this treatment, on the one hand, a mixture of metallic silver with sundry impurities and a notable amount of gold is obtained, while on the other a solution of iodide of zinc is produced, which is standardised and employed in subsequent operations. In this way the valuable substance iodine is used over several times with only a slight loss upon each operation. During the year 1877, 124,500oz. of silver, and 320oz. of gold were recovered by Claudet's process from liquors resulting from the treatment of Spanish and Portuguese pyrites.

The chief production of Spanish and Portuguese pyrites is from the mines of Tharsis, Rio Tinto, and San Domingos, but small quantities of this mineral are likewise obtained from sundry other localities. Of the total annual export from these countries about 600,000 tons, representing 280,000 tons of sulphur, are consumed in this country. In addition to this 54,000 tons of sulphur in the form of brimstone were imported in 1877; thus bringing the grand total of our consumption for that year up to 334,000 tons. A portion of the sulphur imported in the form of brimstone is employed for the preparation of gunpowder and for various other purposes, but a large proportion of it, as well as nearly the whole of that existing in the form of pyrites, is consumed either by alkali makers or by artificial manure manufacturers.

The amount of common salt decomposed by sulphuric acid during the year 1877 was 578,201 tons, while from the resulting sulphate of soda were prepared 223,776 tons of dry carbonate of soda, 169,769 tons of crystallised carbonate of soda, 74,663 tons of caustic soda, and 12,109 tons of bicarbonate of soda. In addition to this 105,529 tons of bleaching powder were prepared from hydrochloric acid resulting from the action of oil of vitriol upon common salt.

The above are large amounts, and represent a money value of about 6,500,000*l*., but in addition to sulphur these mines annually send 28,000 tons of copper, of the value of 1,680,000*l*., into the markets of the United Kingdom; this is above nine times the amount produced in Cornwall in 1877, and six and a half times more than the aggregate production of the United Kingdom during the same year. The sulphur supply of France is chiefly derived from pyrites mines situated near Lyons, while a large proportion of the pyrites consumed in Germany is obtained from Westphalia. The pyrites employed in those countries contains no copper.

EXPLANATION OF PLATES III. & IV.

Plate III. Plan and elevation of an ancient Roman drainage-wheel found at the San Domingos Mine, Portugal. This wheel, which is constructed entirely of wood, somewhat resembles an ordinary water-wheel in which the buckets have been reversed. As, however, both its internal and external rings are continuous, the water, which enters the buckets by the apertures in the sides while they are passing through the trough at the bottom, can only escape through these same openings when raised to the height of the launders, *a*, and, flowing out on either side, is conveyed to another trough, in which is placed a second wheel of similar construction.

It is evident that by the use of a series of such contrivances, placed one above another and all turned at the same time, water can be raised from a considerable depth.

Plate IV. This plate, engraved from a photograph, shows the position of the great open cutting at Rio Tinto looking north. The old workings, which have been cut into during the progress of the excavation, are partly of Roman origin, and in part made by the Spaniards.

THE EVOLUTION OF THE ELEMENTS.

By M. M. PATTISON MUIR, M.A.

THE paper which Mr. Lockyer recently read before the Royal Society suggests many interesting problems to the chemist, but at the same time it awakens within him a feeling bordering upon despair. Are we not to be allowed to retain our belief that the elements are indeed what their name claims them to be? If we allow the physicist to take our elements from us, what possession of ours can we deem secure from his attack?

But, whatever be the result, we must examine the facts, and endeavour to arrive at a just conclusion concerning the nature of the so-called elementary bodies.

It has long been known that the elements may be arranged in certain families or groups, between the members of each of which many remarkable relationships are apparent. Not unfrequently, the numbers expressing the relative amounts of different elements, being members of the same group, which combine together in the formation of compounds, are found to bear certain simple relations to one another. Thus in the family of the halogens the combining weight of bromine is expressed by a number which is almost exactly the mean of the combining weights of chlorine and iodine.

Reasoning on such facts as this, Prout, many years ago, propounded the hypothesis that the elements are all compounds of one kind of matter; that is, that the smallest particles of each element which exhibit the characteristic properties of the element are composed of varying quantities of one and the same primary form of matter. This primary form of matter Prout supposed to be hydrogen. This hypothesis required that the weights of the smallest individual particles of each element should be whole multiples of that of the smallest individual particles of hydrogen. But exact investigation, more especially the investigations of Stas, showed that this was not the case. Stas obtained fractional numbers expressive of the combining weights of those elements which he investigated. It is, however, worthy of remark that the most recent researches of Dumas have shown that Stas overlooked a source of error in his other-

wise wonderfully laborious and refined experimental work; and that a number which is an integer multiple of the combining weight of hydrogen is obtained by Dumas as the combining weight of one of those elements to which Stas assigned a fractional number. Analogies may be traced between the properties, more especially between certain physical constants, of groups of elements, and the properties of substances which are certainly compounds, in varying proportions, of two distinct elements. Further it is known that one and the same element may exist under what are technically termed allotropic modifications; that is to say, that *a* substance which we are unable to decompose into any simpler form of matter may nevertheless exhibit, under varying conditions, different physical, and to a certain extent also different chemical, properties.

Such analogies, details of which I cannot here recapitulate, give a certain degree of plausibility to the theory that the so-called elements are really non-elementary bodies. But such analogies, it may be urged, are shadowy and vague at the best. Twist it how you may, the *fact* remains that we *can* decompose those bodies which we call compounds, and that we *cannot* decompose those bodies which we call elements. No one—triumphantly remarks the orthodox chemist—no one has yet succeeded in decomposing an element. Are you sure of this? Were one to decompose sodium to-morrow, it is by no means certain that one could recognise the products of the decomposition. The ordinary conditions of temperature and pressure would be entirely altered when one succeeded in decomposing sodium; and under these altered conditions no small difficulty would be encountered in endeavouring to determine the fact of decomposition. We may have decomposed the elements, and not have discovered our own success. New problems require new methods for their solution. Anyone who should attempt the study of what I may call the Elementary Elements with the ordinary appliances of the laboratory, would certainly be doomed to failure.

Mr. Lockyer has attempted to solve the problem presented by the elements by combining a new series of experiments with a new method of observation. He has observed the phenomena which occur when certain elements are exposed to the action of intense heat by the aid of perhaps the only instrument at present known, which is capable of giving a satisfactory account of such phenomena—the spectroscope.

The paper in which Mr. Lockyer propounds his views of the nature of the elements is entitled, "Discussion of the working Hypothesis that the so-called Elements are Compound Bodies." At the very outset, therefore, the author is careful to abstain from saying that he has succeeded in decomposing the elements.

Each (undoubtedly) compound body presents us with a characteristic spectrum. The spectra of compounds are characterised by channeled bands and fluted spaces; the spectra of elements (so-called), on the other hand, are characterised by lines, and are comparatively free from bands and channeled spaces.

If calcium chloride be volatilised in a flame the temperature of which is insufficient to cause decomposition of the chloride, no lines characteristic of the metal calcium are seen in the spectrum; if the temperature be increased the calcium lines make their appearance, while the bands due to the chloride fade away, and at last disappear altogether.

The behaviour of calcium chloride may be regarded as typical of that of a compound body when subjected to gradually increasing temperature.

If an element A, known to be mixed with relatively small quantities of another element B, be volatilised, the spectrum of the flame exhibits the characteristic lines of that element (A) which is present in larger quantity, and, added to these, the lines of the impurity (B); the greater the amount of B the greater being the prominence of its lines in the spectrum.

The two cases—viz. that of a compound undergoing decomposition as the temperature increases, and that of a mixture of two elements—may thus be partially differentiated by means of the spectroscope.

Suppose that a compound substance is volatilised at a temperature at which dissociation just begins, and suppose that four lines ($\alpha, \beta, \gamma, \delta$) are apparent in the spectrum; now let the temperature be increased, dissociation proceeds, the line δ disappears, γ thins out, while β becomes prominent; let the temperature be further increased, a process analogous to that already sketched proceeds, until the line α alone remains prominently shown. On reversing the process—that is, on passing from higher to lower temperatures—the spectrum gradually becomes more complex until the original condition is reached. It is, however, to be noted that the line α which is the sole strongly-marked line at high temperatures, does not disappear, but only becomes thinner and less marked at lower temperatures.

Now if we suppose the substance exhibiting the original spectrum (α, β, γ, δ) to be a so-called element, and further if we suppose this element to undergo decomposition as the temperature increases, we should have just such a series of spectra as that described.

In the paper already cited, Mr. Lockyer gives a diagram of certain of the lines in the spectrum of calcium as seen at temperatures varying from that of the Bunsen lamp to that of the star Sirius; and this spectrum he pronounces to be just what

we should expect to find on the supposition that the element has undergone decomposition at the high temperatures of the sun and Sirius.

By a comparison of the lines of calcium as seen in the spectra of Sirius, *a* Aquilæ, and the sun, Mr. Lockyer finds that that line which is all important in the spectrum of the first-named star has become much less marked in the spectrum of the second; in which, however, a new broad, well-marked line has suddenly, as it were, started into being. The characteristic line of Sirius, and that of *a* Aquilæ, he regards as probably indicative of the presence in the former of one, and in the latter of another, of those simpler forms of matter into which, on his theory, calcium is at these exalted temperatures decomposed.

Calcium, as we know it, is thus a product of comparatively low temperature. If the line spectrum of calcium obtained at the temperature of the electric arc be indeed caused by the vibrations of the true atoms—as distinguished from the molecules—of that metal, then the evidence, granting it to be trustworthy in all respects, most probably points to a splitting up of calcium in the atmosphere of Sirius with the production of a form of matter altogether different from anything known to us on this earth.

But it may be urged that even at what are *to us* exceedingly high temperatures, the calcium molecules are not decomposed, and that the line of calcium which is so marked in Sirius and other hot stars is probably due to the vibration of the calcium atoms into which the molecules *are* resolved at these extremely high *stellar* temperatures. Indeed Mr. Lockyer has himself ("Nature," x. 90) stated facts which are not inconsistent with this view.

Now, if this theory be adopted, it is evident that the answer to be given to the query, Are the elements elementary? depends upon the meaning which is assigned to the term "element." If this word be used to designate a substance from which no forms of matter exhibiting properties different from those of the original forms can be obtained, then the elements are, by our theory, not elementary. But if to "element" we give a more exact meaning, and define it as substance, the molecules of which are composed of two or more similar atoms, then the elements are, by this theory, truly elementary.

The controversy regarding the nature of the chemical elements turns largely on the meaning which is given to the term "element."

If we are to regard the effect of greatly exalted temperatures upon the molecules of the elements as consisting in a decomposition of these molecules into their (similar) atoms, we must be prepared to bring forward evidence in support of the pro-

positions—(1) that the properties exhibited by the atoms of elementary bodies are markedly different from those exhibited by the molecules of the same bodies; (2) that the molecules of the elements may remain undissociated into their constituent atoms even at very high temperatures, in other words, that molecules are very stable systems; but (3) that those molecules are decomposable; and (4) that changes in molecular weights may occur among elements or compounds, which changes are correlated with considerable modifications of the properties of those elements or compounds.

I cannot but think that chemists have for many years had evidence before them which might warrant the statement that, *in a certain sense*, the elements are really compound bodies.

The molecule is defined as the smallest part of a substance which exhibits those properties which are characteristic of that substance; if the molecule be subdivided, a substance (or substances) with new properties is produced. We have very distinct evidence in proof of the statement that when two gaseous elements—say chlorine and hydrogen—combine, the combination takes place between the atoms of these elements, which atoms are themselves first of all liberated from the state of mutual combination in which they existed in the molecules of the elements. The act of combination is preceded by an act of decomposition. We call the product of the combination a compound, because its molecule is composed of different atoms: we call the bodies which have undergone decomposition elements, because their molecules are composed of similar atoms.

But we are unable to isolate and examine those atoms of which the elementary molecules are composed. We believe that at the moment of the liberation of an element from a compound that element exists in the atomic condition; we know that at the moment of liberation many gaseous elements are capable of performing actions which they are incapable of performing under ordinary conditions.

We may probably say that in the production of hydrogen from water by the action of the electric current we have three distinct chemical changes occurring: viz. decomposition of the water molecules with the production of atoms of hydrogen and oxygen; combination of the hydrogen atoms with the production of what is known to us as hydrogen; and combination of the oxygen atoms with production of what is known to us as oxygen. In the second and third changes the products of each change are removed from the sphere of action; the change proceeds with great rapidity. We cannot arrest the series of changes at the close of the first; but we know that the introduction of certain substances

sometimes suffices to prevent the second or third change from occurring; and, in place thereof, we are presented with a new chemical change traceable to the action of the dissociated hydrogen or oxygen atoms upon the new substance introduced. Now we call the atoms of the two elements which, by their union, produce water, atoms of hydrogen and oxygen; and, in a sense, this is correct. These atoms, by their union together, produce hydrogen and oxygen respectively; they are therefore atoms of hydrogen and oxygen. But we know very little concerning the exact nature of these atoms *per se*, and all we do know points unmistakably to the conclusion that the properties of these atoms are very different from those which are characteristic of the bodies known to us as hydrogen and oxygen.

I think it would scarcely be too much to say that the whole edifice of modern chemical theory rests upon the hypothesis—may we not say upon the fact?—that the properties of the elementary atoms are markedly different from the properties of the elementary molecules. But, at the same time, facts do not allow us to regard the elementary molecules as composed of atoms of two or more kinds of matter; in other words, all the atoms of hydrogen are certainly possessed of the same properties. The hydrogen molecule may then be regarded as A + A, not A + B. We know the properties of the body A + A; we also know the properties of many other bodies into the composition of which A enters (A + C, A + D, A + E, &c., &c.); but we know very little regarding the properties of A, or B, or C, &c., as distinct from the properties of the compounds of those bodies. We can, it is true, trace modifications in the properties of a compound brought about by the entrance of A, or B, or C into that compound; but we are unable to isolate A, or B, or C, and study its properties when in the free state.

The decomposition of an elementary molecule into its component atoms would thus be a phenomenon not altogether analogous to the decomposition of a compound molecule into its components.

Until recent years we have been content to decide the question of the decomposition of a given substance in a certain reaction by examining the supposed products of decomposition by the ordinary physical or chemical tests. Chemists found no difficulty in distinguishing sodium from soda, iron from rust, mercury from its compound with oxygen; but now we learn that more searching examination must be made before an answer can be given to the question, Are the elements themselves capable of decomposition?

If our elements are non-elementary, they are at any rate much more stable, they are in a sense more definitely marked chemical entities, than our compounds.

The evidence in proof of the second and third propositions laid down on p. 129—viz. that molecules are very stable systems, but that they are nevertheless decomposable—may be said to be furnished by the whole science of Natural Philosophy.

Physical research has determined series of constants for the elementary and compound molecules ; it has shown us how stable these systems are, what definite and clearly marked properties may be predicated of each of them, and how the properties of masses of matter are to be traced to the properties of the molecules of which these masses are built up.

Chemistry, on the other hand, teaches, without doubt or hesitation, that, stable as those molecules are, they are nevertheless decomposed when acted upon by chemical force. To enumerate the leading instances of such decomposition would be to write a treatise on Descriptive Chemistry.

The fourth proposition—viz. that changes may occur in the molecular weights of elements or compounds, which changes are correlated with considerable modifications of the properties of those elements or compounds—demands illustration in some detail.

Apart from the evidence furnished by chemistry in support of this proposition, we know of facts which can scarce find an explanation if this statement be denied. Schuster's recent work on the Spectra of Oxygen obliges us to regard the existence of varying molecular groupings of that element as extremely probable, and tends to discredit the idea that mutual interferences among the vibrations of the same molecules may be a *vera causa* of the totally different spectra of oxygen which he has observed. ("Nature," xviii. 269.) Certain of the changes observed by Dr. Schuster to occur in the spectrum of oxygen are most abrupt and complete, and seem only to find an explanation in the hypothesis that distinct molecular groupings of that element exist even at high temperatures.

But let us look at the chemical evidence in support of our fourth proposition. I suppose everyone regards oxygen and ozone as forms of one and the same elementary body. The marked differences in the behaviour of these bodies are traceable to the fact that the molecule of the latter contains half as many more atoms as the molecule of the former. The molecular weights of oxygen and ozone stand to one another in the proportion of 2 to 3; their molecules are composed of similar atoms, nevertheless the properties of these molecules are by no means identical. Again, the molecular weight of sulphur vapour at temperatures a little above the boiling point of that substance is three times as great as the molecular weight of the same element at considerably higher temperatures. Little is known of the properties of the molecules of sulphur as they exist at either of these temper-

atures; but, from the very marked differences in the properties of this substance when in the solid state, it seems probable that solid sulphur, like gaseous sulphur, is capable of passing from one molecular grouping into another. It may be remarked, in passing, that sulphur yields a line spectrum only at very high temperatures. Phosphorus and arsenic, again, present us with instances of probable changes in molecular weights correlated with decided changes in general chemical and physical properties. Indeed, the whole series of facts grouped under the term *Allotropy* finds its only rational explanation on the assumption that the molecules of the elementary bodies may exist in various more or less complex groupings.

When we turn to compounds we find numerous instances of the same kind. Are not the so-called polymeric compounds of organic chemistry instances of the great change which is brought about in the properties of a compound by doubling or tripling the weight of its molecule?

An oxide of nitrogen represented by the formula N_2O_4 exists; when this compound is heated its physical properties are altered. From a deep-red-coloured gas it is converted into a colourless gas; but the elementary composition of each gas is the same, only the molecular weight of the colourless compound is represented by the formula NO_2. In a sense these two bodies are the same; in another and a truer sense they are different. Spectroscopically considered, there is a marked difference between these compounds.

If the facts which Mr. Lockyer has amassed concerning changes in the spectra of the elements be considered from a chemical standpoint, it seems to me that they are in keeping with other phenomena of a more purely chemical nature, and that both series of phenomena point to the compound nature of the elements, in the sense that the molecules of these bodies are *composed of* particles (atoms) exhibiting properties different from those of the elements themselves, but at the same time that the atoms of any one element all exhibit the same properties.

Whether these elementary atoms are or are not themselves capable of undergoing decomposition must remain an open question.

I do not enter into the question of the meaning of those short lines which Mr. Lockyer states are to be found occurring in the spectra of different elements after eliminating all impurities. Until the methods adopted for eliminating impurities are published in detail, and until we are possessed of exact information with regard to the effect of very small quantities of impurities in modifying the elementary spectra, it seems to me preferable to abstain from framing hypotheses which may eventually be found not to rest on any sure foundation of fact.

Mr. Lockyer's work certainly furnishes us with new proofs of the existence of varying molecular groupings for one and the same element, and of the fact that these groupings become simpler as temperature is increased; but I do not think that we are as yet compelled to believe that essentially new kinds of matter—that is, matter, the molecules of which are composed of atoms other than those composing the molecules of the original matter with which we started—are produced, even at extremely high temperatures. We may, perhaps, regard the molecules of our elements when in the gaseous state at moderate temperatures as consisting each of distinct atoms; as temperature increases some of these molecules are partially decomposed, but without the production of new atoms, until, at extremely high temperatures, the greater portion of the mass of matter present exists in the true atomic condition. It may be that at yet higher temperatures, or under altogether different conditions, these atoms would themselves be decomposed, and that this process would proceed, until finally the primary atom, of which all *our* elementary atoms are but compounds, would be reached.

On this view the formation of so-called elementary atoms, and again of so-called elementary molecules, would mark resting-places in the process of evolution, points of stable equilibrium in the cycle of development. But this is merely hypothetical.

M. M. Pattison Muir.

THE STRUCTURE AND ORIGIN OF LIMESTONES.*

By H. C. SORBY, F.R.S., President of the Geological Society.

IN his Anniversary Address, delivered at the annual meeting of the Geological Society in February, the President, Mr. H. C. Sorby, F.R.S., departed somewhat from the ordinary form of Presidential addresses, and laid before the Fellows the result of some laborious original researches which seem to open up a new field of geological investigation, or at all events to suggest the application of a perfectly new method of research to the solution of questions which have certainly already, to a limited extent, attracted the attention of geologists. He devoted his address to the consideration of the structure and origin of limestones, relying mainly on his own observations, but incorporating general facts derived from other sources.

Since, in order to properly understand the nature of the various constituent fragments of which many limestones are composed, it is necessary to know the organic and mineral constitution of the different living calcareous organisms, this question was first considered *from a somewhat novel point of view*, and very great attention was paid to their optical characters, by using a new form of apparatus, specially designed for such inquiries. The conclusion arrived at was that the microscopical structure depends on both organic and mineral growth, the influence of the one or the other varying greatly in different organisms. Much attention was also directed to their mineral constitution, so as to determine whether the carbonate of lime exists in the form of calcite or aragonite. The results are in some cases very curious and interesting, even from a biological point of view. Certain large natural groups are composed of calcite, and others of aragonite, whilst others are made up of well-marked layers of the two minerals. In a few cases they occur too intimately mixed to be separated.

* We need hardly apologise to our readers for laying before them this abstract of a most interesting and important memoir. For all but the first paragraph we are indebted to the kindness of Mr. Sorby.

A knowledge of the true mineral constitution is of the highest importance in studying the changes which occur in fossils and in the investigation of limestones, since the final results depend almost exclusively on the original mineral constitution, and vary very greatly, according as the organism is calcite or aragonite. This is due to the fact that calcite is in a state of stable equilibrium, and cannot be changed to aragonite; whereas aragonite is relatively in a state of unstable equilibrium, can be changed to calcite, and usually is so changed, in limestone rocks. This circumstance has given rise to a complete difference in the state of preservation of many fossils. When they were originally calcite they may have been further consolidated, although retaining their original structure and optical properties; whereas when they were aragonite they have sometimes been completely removed by solution, and in other cases are changed into a mass of crystals of calcite, and have lost their original microscopical and optical characters. The general structure of various recent and fossil organisms was then considered, with special reference to the identification of the minute fragments occurring in limestone rocks. When they were originally composed of calcite, and have retained their original characters, there is usually little difficulty in identifying them more or less definitely, according to their particular nature, so as to be able to form a good opinion as to the constitution of each particular limestone.

The various facts connected with the disintegration of shells, corals, and other organisms are of great importance in studying limestones, since without an adequate knowledge of the manner in which they decay and fall to pieces very inaccurate conclusions might be formed respecting the origin of calcareous deposits. The results mainly depend on original structure, and on whether they are composed of calcite or aragonite.

The next questions considered were the manner in which the external form of minute fragments is preserved in limestone, and the various chemical changes occurring after deposition or consolidation. When their structure is preserved there is no difficulty in recognising the fragments; but when they have become almost equally crystalline with the surrounding material, their outline is shown by a thin layer of dirt, or by a zone of finer crystalline texture. After deposition and consolidation certain changes have often occurred, the chief of which are the replacement of more or less of the lime by magnesia or by iron compounds. After having thus established the general principles necessary for their accurate study, Mr. Sorby entered on a description of our various English limestones, in descending order.

The main object was to ascertain, as far as possible, the exact

nature of the material from which each particular rock was derived. Some beds are mainly composed of definite fragments, so as to be analogous to sands, and then the true nature of the various organisms from which the fragments are derived can be ascertained, provided they were originally calcite; whereas, if they were originally aragonite and their structure is lost, very often all that can be said is that they were portions of aragonite shells or corals. Many associated beds are or were composed of fine granules, and analogous to clays. In many cases these have in all probability been derived to a great extent from aragonite organisms decayed down into small granules of calcite, and it is quite impossible to further identify the material.

The structure and origin of oolitic grains were dwelt upon at some length. Usually they are evidence of true chemical deposition, since they are of simple crystalline growth, quite independent of living organisms. They occur of three distinct types, viz.: those composed of aragonite, like the Carlsbad *Sprudelstein*, having a concentric structure without any radii, giving rise with polarized light to a black cross optically positive; those which are composed of calcite, having a radiate structure, and giving rise to a negative black cross, which are the predominant and characteristic type of our oolitic rocks; and those which have recrystallized since their original formation, which in all probability were originally aragonite, subsequently changed into calcite.

After describing the chief points of interest connected with the leading limestone rocks of our country, Mr. Sorby collected together the results into two tables, the more condensed of which may here be given:—

Name of rocks.	Chief constituent fragments, &c., in descending order.
Cretaceous . .	Shell prisms, Foraminifera, Coccoliths.
Wealden . . .	Freshwater aragonite Mollusca, Entomostraca.
Jurassic . . .	Chemical deposits, aragonite Mollusca and Corals, Brachiopoda, Echinoderms, shell prisms.
Permian . . .	Original structure lost by dolomitization.
Carboniferous .	Encrinites, Brachiopoda, Foraminifera, Corals, and Polyzoa.
Devonian . . .	Encrinites, Corals, and allied organisms.
Silurian . . .	Encrinites, Corals and Polyzoa, Brachiopoda, Trilobites.
Metamorphic. .	Original structure lost, quartz and silicates formed *in situ*.

He concluded as follows:—

"On examining these tables, especially the more detailed one, it will be seen how remarkably and characteristically our limestones differ from one another. There would usually be little difficulty in deciding the general age of any characteristic, somewhat coarse-grained, specimen. Though this difference must to a great extent have depended on the nature of the

organisms living at each period, yet it must also have depended on the accompanying mechanical and chemical conditions of the water in which the deposits were formed. The structure of each rock was, therefore, dependent on two most important circumstances, and we need not be surprised to find the results so varied and characteristic. Passing upwards from the earlier rocks, we may often trace a gradual change, broken here and there by a complete contrast, which is in perfect agreement with results arrived at from a totally different class of facts. On the whole, this is perhaps the most important conclusion that we can at present draw from the subject before us. Possibly further research may teach us much more, since I am quite sure that much remains to be learned. In fact, long as I have studied these questions, and long as this address has been, I know quite enough of the facts to be convinced that it is only a sort of first attempt and rough sketch of a very wide and complex subject."

THE SUPPOSED NEW CRATER ON THE MOON.

By E. Neison, F.R.A.S.

NEAR the centre of the surface of the lunar hemisphere which is turned towards the earth, there is an open region which is called by astronomers the Mare Vaporum. It is a tolerably level plain, with a grey coloured surface, broken by some small hills and craters, and traversed by a number of low, gently sloping ridges. It is bordered on all sides by elevated hill lands, plateaux, or lofty ridges. This region is from its situation so favourably placed for observation that all its features can be observed and its appearance delineated with great facility.

In the southern portion of this grey plain, the Mare Vaporum, there is a small crater some five miles in diameter, which was named Hyginus by Riccioli, the founder of the present system of lunar nomenclature. The crater lies in the centre of a level portion of the Mare Vaporum separated from the rest by some broad valleys and ridges of a dark grey colour. Running right across the plain a very remarkable formation was discovered by Schröter, the celebrated Hanoverian astronomer and the rival of Sir William Herschel. This formation, which is termed a cleft or rill, resembles a great dry canal or gorge, or still more what is in America termed a Cañon. It is a sharply marked gorge or ravine over a thousand feet deep, and about three-quarters of a mile broad, with steeply falling sides. It extends for nearly 150 miles right across the plain, bursting through all obstacles, and ending on the great grey plain called the Mare Tranquillitatis. This rill was the first of these extraordinary formations which was discovered, so that its discovery excited much astonishment and led to the entire region being examined with great care. Since then many similar though more minute formations have been discovered, and in particular a most intricate system of these rills was discovered by Beer and Mädler in the open plain to the south of Hyginus. In consequence of these discoveries this portion of the lunar surface has been most

attentively studied, and its appearance has been repeatedly drawn, and the whole region mapped with especial care. Consequently it is a portion of the surface of the moon whose appearance and configuration are known with much exactitude.

For many years it has been the opinion of the great majority of astronomers that no apparent changes of any magnitude were now taking place on the surface of the moon. Nor is it difficult to understand how this opinion has become generally prevalent. It originated in a summary by the celebrated selenographer Mädler of the differences in the constitution of the moon and earth, in which he forcibly pointed out the impossibility of the view held by the earlier astronomers, which was that the moon might be a mere copy of the earth. In these remarks Mädler indicated that, compared with the earth, with its large oceans, abundant vegetation and numerous fauna, the moon would be a lifeless desert. In a condensed and far less qualified form these remarks were copied into all the text-books of astronomy, and constituted the basis of the views commonly held by astronomers.

They gradually came to look upon the moon as an arid lifeless desert, an extinct volcano. Nor is the real condition of the moon, when seen through a telescope, such as to remove these views. "Its cold, still, apparently unchangeable surface, so utterly unlike what the earth might be supposed to appear as seen from the moon, convinces the casual observer that the world he then sees is utterly unlike the world he knows. He looks for immense cloud masses floating in a dense atmosphere: for wave-tossed seas and winding broad rivers, and there are none; searches for luxuriant forests and green prairies, and they are absent. This is enough, and he retires from further contemplation of the 'airless, waterless, lifeless, volcanic desert' of the text-books."

It is, however, a noteworthy fact that this is not the view entertained by those who have devoted much time to the study of the condition of the lunar surface. These astronomers believe that they have found a number of facts which in their opinion indicate that great physical changes are slowly taking place on the surface of the moon. Schröter, Lohrmann, Gruithuisen, Mädler, Schmidt, five most famous selenographers, men who have devoted many years to observing the moon, have all pointed out appearances which they had observed, and which they believed indicated instances of real change taking place on the lunar surface.

Yet the great body of astronomers still retained their opinion, although they had not devoted any special attention to this question; they contended that no change had been proved to have occurred, and refused to alter their opinion that no change

was possible until some change had been proved to have taken place.

Within the last few years some important instances of probable lunar change have been made known. Thus the crater Linné described by Lohrmann, Mädler, and Schmidt as six or seven miles in diameter and very deep, has now quite disappeared, leaving only a white spot surrounding a small crater of scarcely one-tenth the former area. Other instances have also been made known of the disappearance of craters which had been described by the earlier selenographers, and of the appearance of other craters in places where no crater had been seen before. In none of these cases is the evidence perfectly decisive; there is in all cases room left open for doubt, and consequently they have been waived aside by astronomers in general.

Several years ago it was pointed out that to obtain a decisive instance of a real physical change of this nature, it would be essential for a crater of some size to make its appearance in or to disappear from one of some three or four regions in the moon which had been thoroughly well studied. There are certain small portions of the lunar surface which have been assiduously studied and drawn by many selenographers, including several well-known living astronomers. It was then pointed out that the region around Hyginus, Triesnecher, and Ukert had been so thoroughly well studied that were a crater of three or four miles in diameter to appear or disappear in this portion of the moon, the fact could be established with certainty. It was also pointed out that these regions formed only one-thousandth part of the visible surface, so that though there might be numerous changes occurring on the lunar surface, it would be unlikely that one should occur in this comparatively small area.

On the evening of May 19, 1877, a German astronomer, Dr. Hermann J. Klein, was examining the portion of the lunar surface around the well-known crater, Hyginus, using a first-class telescope of $5\frac{1}{2}$ inches aperture. The moon had not quite reached its first quarter, so that the sun had only just risen above the horizon of this portion of the moon, and its rays fell very obliquely on the surface, throwing every inequality into broad relief from the long shadows that they cast. For nearly twelve years Dr. Klein had been in the habit of observing this region, so that it was perfectly familiar to him, and he was well acquainted with its appearance. To his great surprise he caught sight of a large black crater filled with shadow, lying to the north of Hyginus, and near the border of the level plain. He felt certain that this crater had not existed on any previous occasion when he had examined this region, for it seemed to be so conspicuous that he was positive he could not have over-

looked it. In this region there are a number of small craters only a mile or so in diameter, and requiring a good telescope and steady air to be seen with ease. The day was not favourable, and only one of these craters could be seen, yet this strange object was most conspicuous and nearly three miles in diameter. Dr. Klein had often seen the small craters, but he had never before seen this great black crater-like object; and it appeared certain to him that he could not have so often seen these small craters and yet have overlooked this great giant right in their very midst. *Was this crater new?*

The great importance of this observation could not be overlooked. It strongly pointed to a new volcanic eruption on the lunar surface. That the object must be new seemed certain to Dr. Klein, for he could not see how it could have been overlooked not only by himself, but by all those who had previously observed, drawn, or mapped this region. It was not seen for a certainty by Schröter, Lohrmann, Gruithuisen, Mädler, or Neison, or they would have mentioned or drawn it in their works on the moon. Was it new? Had it been reserved for him to give to astronomers what they demanded before changing their opinion, a decisive proof of a visible real physical change on the lunar surface?

It must have been with anxiety and impatience that Dr. Klein awaited the next night, when he might again see this strange formation, for during the night all sorts of doubts and difficulties must have sprung up. But the weather was unfavourable, and he could not resume his observations. Day after day went on, and clouds still prevented his continuing his observations, so that he was compelled to wait for the next lunation.

June 18 was the first day that this portion of the moon would be seen under a low illumination, though even then under far less favourable conditions than on May 19. The day arrived and it was fine, and Dr. Klein turned his telescope on this region. Had or had there not been some extraordinary error in his last observation? Would or would he not see a great black crater where no such crater had been seen before? He looked, and in the place where the crater had been visible on the previous occasion, there appeared a great black spot with an ill-defined nebulous border. Was this the great black crater? It was certainly in the right place, and near it he could see the small craters which he had so often seen before. Still on the previous occasion he had seen a distinct crater-like formation, whereas all that was now visible was a blackish spot. It was true that the sun was considerably higher now than before, which would tend to mask the crater-like appearance of the formation. This variation was very perplexing, was this object really a crater or merely a blackish spot? In either case it

seemed to be new, for it had never been seen by any previous observer, whereas it was still far too conspicuous to be overlooked. The moon quickly setting put an end to his observations.

On the next evening Dr. Klein again turned his telescope on this region, but to his surprise the crater-like spot had completely disappeared.

Dr. Klein awaited with impatience an opportunity of obtaining further observations with the view of elucidating this mystery. The Fates were unpropitious. A spell of bad weather set in, and lunation after lunation went by, and no chances were afforded of obtaining additional observations. At last, on November 13, a short observation was obtained of this region on the second day after sunrise, and an ill-defined dark spot was seen in the place of the strange formation, which had looked like a deep crater when seen at sunrise. The next day came, and the spot had again disappeared. It was evident that it was only to be seen for a short time after sunrise, and disappeared when the rays of the sun fell more perpendicularly on the surface. It was again visible on December 13, but only as a dark spot, the sun having then risen some 15° above the horizon of this part of the moon.

These observations threw a good deal of additional light on the nature of this mysterious strange formation. Dr. Klein came to the conclusion that it was a great deep black crater, surrounded by a very low wall and sinking deep into the surface. It appeared to be elliptical in form, and to be over three miles in diameter. At sunrise it seemed to be so conspicuous, that Dr. Klein felt certain that had it then existed it could not have been overlooked by Schröter, Lohrmann, Gruithuisen, Mädler, or Neison, when they had so repeatedly drawn the region. Moreover, he was sure from his own observation that it did not exist prior to 1876. It was then a new formation.

To an experienced observer the features presented by this crater were not new. They instantly recalled to his mind the peculiar crater-like depressions of the far south-west. Far away on the south-west quadrant of the moon, in the wild regions around Fraunhofer, and near Stiborius, there are known to exist a number of deep crater-like formations, with low walls, or even without walls, and penetrating with steep sides deep into the lunar surface. When seen just after sunrise, when the solar rays fall very obliquely on the surface, these formations are seen in the form of deep black craters. As the solar altitude slowly increases and the rays fall less obliquely on the surface, these craters grow more indistinct, and take the appearance of dark grey or blackish spots with ill-defined borders. Gradually, as the solar altitude increases, these spots grow more and more indistinct, and two or three days after sunrise they completely

disappear, and as long as the solar rays fall thus perpendicularly on the surface they remain invisible. These are the very characteristics which marked the new crater which had been seen by Dr. Klein; and his observations seemed to strongly indicate that a crater of this kind had suddenly made its appearance on the level plain north of Hyginus. This rendered the discovery still more extraordinary, for no similar formation was known to exist within nearly a thousand miles of this spot. In fact, it was supposed that they were strictly confined to a region in the far south-west of the moon.

For some time Dr. Klein was unwilling to publicly announce his discovery, being well aware that the great majority of astronomers were of opinion that the period was long passed in which such changes were possible. He wrote, however, Dr. Julius F. Schmidt, the eminent selenographer of Athens, and he learnt from him that though he had frequently observed and drawn this portion of the moon at different times between the years 1860 and 1875, yet he had never seen any trace of such a crater. Shortly afterwards he learned that on again observing this region Dr. Schmidt had at once seen the new object described by Dr. Klein. He determined to publish an account of his observations.

Dr. Klein sent an account of his discovery to the editor of the "Journal of the Selenographical Society," with the view of obtaining the co-operation of the members of the Society in observing this new object. At the same time he published an account of his discovery in two German astronomical periodicals, the "Wochenschrift für Astronomie" for March 27, 1878, and "Sirius" for April 1878.

Dr. Klein's announcement that a great black crater, about three miles in diameter, had suddenly made its appearance on the level plain to the north of Hyginus, where it formed as conspicuous an object as any in this region, instantly aroused the English selenographers. Every extant observation was examined, and every available drawing and map most carefully inspected, but no trace of a crater of this description could be found in the position assigned to it by Dr. Klein. It was thus certain that none of our leading selenographers had ever seen such an object, and this was justly regarded as tantamount to saying it could not have existed prior to 1876, for it was regarded as impossible that such a crater could have existed, and have escaped being seen by astronomers who had frequently observed very much smaller and far less conspicuous objects all around its place. It was further announced that Mr. Neison had repeatedly examined this region between 1870 and 1876, and was certain that there did not exist at that period a great black crater three miles in diameter, and as conspicuous as Hyginus, as the new object was

described by Dr. Klein. Not a trace of such a crater could be detected in any of the photographs, though this was no more than might be expected, for they do not show such objects near the terminator where the crater would be alone visible as such. This combined testimony was regarded by selenographers as establishing for a certainty the fact that no such crater existed in this place prior to 1876. Had then the appearance of a new crater been established, and an instance of a real physical change decisively made out? Not quite. It had yet to be proved for a certainty that such a crater really did exist.

That there was some object in this region which had not been seen before was rendered certain by Dr. Klein's account; but was it an object which could not have been overlooked? If it were really a great deep crater of the character described by Dr. Klein, then it was certain it could not have been overlooked. It must be new. But if it turned out to be a mere shallow depression, or a mere dark spot, it was not likely to have been overlooked, but it might have been, and it would be impossible to regard it as being certainly new. If it were merely a hollow, or a surface marking, or some small inconspicuous depression, then it might have been overlooked. Which of these was really its character? Selenographers awaited with impatience an opportunity of settling this point by making additional observations.

April, May, and June came and went, but the weather was so unfavourable that no observations of any importance could be made in England. Where the crater ought to be could be seen a dark spot such as was described by Dr. Klein. So far his observations were confirmed, but the weather had prevented this region being seen at sunrise when alone the new object was to be seen as a crater. In Germany, however, Dr. Klein was able to see the crater again at sunrise, and he described it as a deep black crater of considerable size and as conspicuous as Hyginus. If therefore these observations of his were confirmed, it must be a new formation.

During the summer and autumn of 1878, the weather continued so bad that no suitable observations of the new crater could be obtained in England. A discussion arose, however, on the question, whether this crater of Dr. Klein's was really new or not. It was pointed out by some astronomers that in the lunar photographs, near the place where it was thought that Klein's crater ought to be, there were shown some white and some dark spots.

Some astronomers thought that one of these white spots must be the supposed new crater, others thought that one of the dark spots was really the crater. After thus identifying the crater on a lunar photograph taken prior to 1876, it was argued that the crater could not be new, and that it showed that no reliance

could be placed on the testimony of those who stated that the crater could not have existed prior to 1876, or they would have seen it. In reply to these objections it was urged, that those objects shown in the photographs were not Dr. Klein's crater, but were well known lunar markings. It was stated by Mr. Neison that he had examined all these photographs, and that in the true position of Dr. Klein's crater the photographs did not show a single object, and that the different dark and light spots shown all round the place of the crater arose from well-known markings on the moon, all of which were shown on his large map made from his observations prior to 1876. This statement was confirmed by Dr. Klein himself, with the important addition that the new crater discovered by him was always completely invisible when the illumination of the moon was such as it was when these photographs were taken.

It may be remarked, however, that this supposed visibility of Dr. Klein's crater on the photographs is of little moment, even were it possible to satisfactorily identify such an object on the photographs. The real point is this, that before 1876 no great deep black crater was visible at sunrise in this part of the lunar surface, though if it had existed it could not have escaped detection, whereas now according to Dr. Klein such a crater does exist, and is visible. The fact of its being visible sometimes after sunrise as a dark spot, though of great interest, is of far less moment, for there are known to be several such dark spots in this region, and two or more might be confounded, and it would be impossible to say that an ordinary small dark spot had not been visible in this region prior to 1876.

On October 3rd the new crater was seen by Herr Bonffay; on November 2nd the new object was seen as a conspicuous crater-like depression by two English observers, Messrs. Rand Capron and Baxendell; and since then it has been seen as a dark spot by several observers. There is, consequently, no doubt that there is some object in this position. Its real nature is not yet established.

It is unfortunate that when the crater has been very obliquely illuminated, and when alone its crateriform character could be ascertained, then it has only been seen by observers who (with the exception of Dr. Klein) are not accustomed to observe the moon, and who are not specially acquainted with this portion of the lunar surface. There are several selenographers who ought to be thoroughly acquainted with this portion of the moon, and who could at once say whether this object of Dr. Klein's was a true crater, which could not have been overlooked by them, or was a small shallow inconspicuous object which might readily have escaped detection. The persistent bad weather, however, seems to have hitherto prevented their seeing this region under suitable

illumination, and consequently the true nature of this remarkable object remains to be determined. Further information, therefore, must be obtained before a decision can be arrived at whether this crater of Dr. Klein's is or is not a new formation.

The great importance of this question is too obvious to need being pointed out, for it would immensely increase the importance of this branch of astronomy, and at once raise selenography into one of the most important fields of astronomical research as it is already one of the most interesting. Let it once be established that great physical changes in the conformation of the moon are still in active operation, and it would lead to the lunar surface being most assiduously studied. And as it has been well remarked by both the eminent selenographer Mädler and the distinguished geologist Phillips, there is little doubt that the careful study of the features presented by the lunar surface would lead to most important discoveries being made as to the career, past, present and future, of not only our satellite the moon, but of its primary, the earth.

ENTOMOLOGY.[1]

By the EDITOR.

"I SHOULD ha' forgot it; I should certainly ha' forgot it," was the exclamation of Mr. Samuel Weller on a well-known occasion; and it was the same phenomenon which acted thus upon the mind of that distinguished character that recalled to the recollection of the present writer an almost forgotten intention to say a few words in praise of the study of Entomology. I can hardly hope to produce anything at all equal to those flowers of eloquence which bloomed in Mr. Weller's valentine under the genial influence of "nine-penn'orth of brandy-and-water, luke;" but the spring of the year seems to be a peculiarly appropriate season for the publication of a plea for entomology, a department of natural history the scientific importance of which seems hardly to be sufficiently recognised, and I must trust to the good nature of the reader to forgive any deficiencies that may be apparent in the present article under the comparison that I have so injudiciously provoked.

It must be confessed that there were few indications of spring in the weather at the time when the shopwindows this year displayed those tempting absurdities which, we may presume, a good many people find pleasure in sending to each other, seeing that their delivery leads to the practical result of a great increase in the postman's labour; but, on the other hand, the matter to which I wish to direct the reader's attention has its interest at all periods of the year, although there is, perhaps, a special fitness at the present season in delivering a lecture on the study of entomology. For while it is quite true that even in winter many exceedingly interesting insects are to be met with, generally by hunting them up in their places of concealment among moss, under the bark of trees, under stones, and in other recondite places, it must be confessed that the entomologist's great harvest is to be reaped during the other three seasons of the year, and it is certainly advantageous for the beginner to commence his researches at a time when the

abundance of insect life surrounding him in all directions, and forcing itself, as it were, upon his notice in all his walks, offers a constant succession of objects of interest. In the spring, when all nature wakes from the torpor of winter, this is especially the case. With the first days of sunshine thousands of insects make their appearance—the solitary bees and sand-wasps are to be seen emerging from the galleries in which they have passed their early stages, or flying busily about the flowers and hovering over the banks of sand or clay in which they are about to burrow and deposit their eggs; the brilliant tiger-beetles flit about sandy lanes and commons, sparkling in the sunlight like living emeralds; the field-paths glitter in the morning with the small carnivorous beetles commonly known as "sunshiners," whose place is taken in the evening by their larger relatives, the great ground beetles (*Carabus*); plenty of that multitude of beetles of various groups which deposit their eggs in the droppings of horses and cattle are seen flying steadily through the air; on the surface of still waters the whirligig-beetle is enjoying his mystic circular dance, while from time to time the water-beetles come quietly up, and, after applying their tails for a moment to the surface, in search of air, plunge down again into the depths; or the water-boatman (*Notonecta*) hangs for a short time in a similar position, with his long oar-like legs outspread ready for action on the least alarm; and even a few early butterflies, the beautiful "Brimstone" especially, flutter gaily through the air. On a fine day in spring or early summer the entomologist perhaps of all men in this *blasé* nineteenth century realises most fully the charm of old Izaak Walton's pastoral. Entomology may not improperly be denominated the modern "Contemplative Man's Recreation."

It is unnecessary, and would lead me too far, to expatiate on the insect phenomena of the summer and autumn—on the succession of new forms which replace or mingle with those of the spring-tide, and keep the interest of the entomologist alive until quite late in the year. But there is one point which I would urge upon the beginner in the study of insects, and that is to yield to that instinct which is sure to prompt him at first to collect and gain some knowledge of *all* the forms which attract his attention, before sitting down to the special investigation of some one department which is almost equally certain to be the result of his further progress. It is only by this means that the full benefit of the study which it is my desire to recommend to the reader can be obtained.

It is, perhaps, hardly necessary at this time of day to vindicate the study of entomology, or indeed of any branch of zoology, from the charge of being merely the amusement of contemptibly frivolous minds. A century ago such a notion

was by no means uncommon; and although some writers of that age occasionally touched upon subjects of natural history, this was done with a tone of conscious superiority, which sounds almost as if the gentlemen in question felt that they were patronising Nature by condescending to take any notice of her productions. The entomologist, especially, was always somewhat of an object of pity, a sort of harmless lunatic. Dr. Johnson, we may fancy, would place him just a step or two higher than that young man who was last heard of "running about town shooting cats"; with others he was a *virtuoso*, and we all know pretty well what that term indicated; and even Richardson, the mild idol of the tea-table, refers to natural-history pursuits in a fashion which may be taken to indicate pretty clearly the estimation in which they were held in his day. Lady G., Sir Charles Grandison's sister, writes of her husband: "He will give away to a *virtuoso* friend his collection of moths and butterflies: I once, he remembered, rallied him upon them. 'And by what study,' thought I, 'wilt thou, honest man, supply their place? If thou hast a talent this way, pursue it; since perhaps thou wilt not shine in any other.' And the best of anything, you know, Harriet, carries with it the appearance of excellence. Nay, he would also part with his collection of shells, if I had no objection. 'To whom, my lord?' He had not resolved. 'Why, then, only as Emily is too little of a child, (!) or you might give them to her.' . . . . . . He has taken my hint, and has presented his collection of shells to Emily; and they two are actually busied in admiring them; the one strutting over the beauties, in order to enhance the value of the present; the other curtseying ten times in a minute, to show her gratitude. Poor man! when his *virtuoso* friend has got his butterflies and moths, I am afraid he must set up a turner's shop for employment." There! isn't the badinage delightful? And, as if to point the moral, "a fine set of Japan china with brown edges" is spoken of in the same letter in terms of appreciation, although the fussiness of my Lord G. in connection therewith receives a stroke or two. The gentle, moral Richardson evidently thought entomologists a somewhat contemptible race, as, at a later period, did that redoubtable satirist, "Peter Pindar," whose descriptions of Sir Joseph Banks in pursuit of the "Emperor of Morocco," and boiling fleas to ascertain whether they were lobsters, are pretty well known.

If we consider the origin of this contempt, which undoubtedly until comparatively recent times did pursue the unfortunate entomologist, we may pretty safely refer it to two causes,—in the first place, the ignorance of all natural-history matters which must have prevailed in a society in which Oliver Goldsmith shone as a naturalist; and in the second to the fact, that most of the entomologists of the time were really mere collec-

tors of insects as pretty things, to whom, therefore, the term *virtuoso* was peculiarly applicable. But the mere collecting of insects is surely at least as good as any other manifestation of the *cacoëthes colligendi* which is so general an affection of humanity, and which leads to the accumulation of books in good bindings, of coins and medals, old china, statues, and other works of art, by people who have no true appreciation of their value. Even the making of butterfly-pictures seems to be almost as intellectual an employment as the collecting of postage-stamps, which has been prosecuted with considerable zeal by a good many people in the present day. To this general ridicule we must, I think, add, in the case of entomology, that the practical collecting of insects for amusement was looked upon as a sort of sport, and therefore contemptible, because the game was so small: just on the same principle that the quiet angler is looked down upon by those who love "the noyse of houndys, the blastes of hornys, and the serye of foulis, that hunters, fawkeners, and foulers make," according to Dame Juliana Berners. Although the marked feeling here alluded to is happily extinct, its effects, no doubt, to some extent survive, and it may be due to them that professed zoologists at the present day unquestionably know less of insects than of any other class of animals.

Nowadays it will hardly be formally denied that all branches of natural history are well worth studying; and it is the object of the present article to show that entomology, however it may have been maligned in the past, presents certain advantages to the intending student which may well give it in many cases a preference over other departments of zoology. It has already been stated that entomological researches may be carried on all the year round, and it may be added that there is no locality in which they cannot be pursued—a matter of no small consequence to that great majority whose connections or avocations tie them down more or less to one spot. Even in the heart of large cities some representatives of most of the orders of insects may be met with; and suburban gardens, if at all favourably placed, may furnish quite a large collection to those who work them systematically. The late Mr. James Francis Stephens used to relate that he had obtained over 2,000 species of insects in the little garden at the back of his house in Foxley Road, Kennington. Short excursions, which the custom of Saturday half-holidays renders particularly easy, will enable the entomologist who is condemned to a town life to have many opportunities of adding to his stores both of specimens and of knowledge, whilst the resident in the country may find fresh objects of interest in whatever direction he turns.

Further, the means of procuring these objects are very simple

and inexpensive. The student of marine zoology may be left out of the question, because a seaside residence is more or less essential for his pursuits; but even he cannot do very much practically without dredging, which is a troublesome and expensive operation. On the other hand, the ornithologist must either buy his specimens, or drag his gun about with him wherever he goes, on the chance of falling in with some desirable species; the representatives of other classes of animals than birds and insects in inland situations in this country are too few to enable them to come into competition with the latter. The entomologist requires only a net or two and a few pillboxes and bottles, all of which he can carry in his pockets, to set him up in his pursuit; and when he brings home his prizes he wants only two or three papers of pins, a few pieces of cork, and a close-fitting box or two lined with cork, for the preparation and preservation of his specimens. No doubt, with his progress, the appliances made use of by the entomologist will increase in number and complexity; but the student of most other branches of zoology must either skin and stuff his specimens or preserve them in spirit or some other fluid, and his collections will in consequence cost more and occupy much more space.

As the characters upon which insects are classified are nearly all external—that is to say, derived from parts which may be investigated without destroying the specimens—their systematic study is very easily pursued, whilst their small size, by enabling a large number of species to be brought together within a very limited space, affords peculiar facilities for the comparison of characters, and for the recognition of the agreements and differences presented by the members of the same group. If the entomologist chooses to go further, and to investigate the anatomical structure of the objects of his study, their smallness may at first sight seem to be an obstacle in his way, but this is soon got over, and it then becomes an advantage, seeing that, owing to it, such researches may be carried on anywhere, without the necessity of devoting a special apartment to the purpose, which can hardly be dispensed with in the case of vertebrate animals. Moreover, as the hard parts of insects are nearly all outside, their anatomy, which is perhaps the most interesting of all, may be studied with the greatest ease, and in fact the most instructive parts of the morphology of insects are those which it is essential for the student to know in order to understand their classification. Thus, for example, the investigation of the structure of the mouth in insects of different orders will give the student a clearer idea of the meaning of the term *homology*, and of the changes which the same parts may undergo in animals, than could be furnished him by any other examples; and the series of modifications, occurring not only in the various types, but even

in the same individuals, at different stages of their development, is most striking and instructive.

Again, these developmental stages, the transformations or metamorphoses of insects, some knowledge of which is also necessary for the comprehension of the classification of these animals, furnish a study of never-ceasing interest, partly for its own sake, partly as giving the student a clear conception of the phenomena of metamorphosis, which plays so important a part in other departments of zoology, and partly from the views which it opens up as to the natural history of insects and their complex relations to the world outside them. Here the parasitism of so many insects in their preparatory stages may especially be cited, as affording an endless and most instructive subject of investigation; and the whole series of phenomena comprised in the life-history of insects affords an easily studied representation of the great system of checks and counterchecks which pervades all nature in the destruction of herbivorous by carnivorous animals, of the latter by other carnivores, and of both by parasites. Indeed, no other class of animals exhibits these inter-relations and mutual reactions between different organisms so clearly and so multifariously as the insects. Besides the ordinary division into herbivorous and carnivorous forms, we find many of both series restricted to one particular article of diet, or to nourishment derived from a very few species nearly allied to each other; in their modes of activity insects reproduce those of all other classes of animals, combined with a few peculiar to themselves; the insidious phenomena of parasitism are displayed by them with a perfection of distinctness such as we meet with nowhere else; and their influence is exerted in a thousand ways for the modification of other organisms with which they are brought into contact. Thus, according to Mr. Darwin's theory, which is adopted by a great many naturalists, the action of insects is of the utmost importance in the fertilisation of flowering plants,—nay, as an extension or corollary of this view, we find some who are prepared to maintain that insects are the cause of the development and beautiful coloration of flowers. All these different aspects of the relations of insects to the world outside them open up an infinity of paths for investigation, each of them leading to most interesting and important results, and calling for an exertion of the powers of observation which, as a mere mental training, cannot but produce the most beneficial results. Moreover, so much remains to be done in most of these fields of research, that almost every earnest worker may look forward to the probability of ascertaining some previously unknown facts of more or less importance—a hope which is not without its influence upon most minds. By the knowledge of the facts involved in the recognition of this general system the

entomologist may often render important services to the farmer and the gardener, and thus give a direct practical value to his studies. Nearly every production of the field or the garden is subject to the attacks of insects, which, in case of their inordinate increase, may easily cause very great damage to the crops, or even destroy them altogether. In the face of such enemies the cultivator is often quite helpless, and not unfrequently mistakes his friends for his foes, attributing the mischief produced by concealed enemies to more prominent forms, which are really doing their best for his benefit. In such cases the entomologist may step in to the assistance of his neighbour, indicate to him the real cause of the damage, and in many instances the best remedy, and the best time to employ it.

The asserted influence of insect agency upon the forms and colours of flowers, referred to above, leads to other considerations which may serve to give additional importance to the study of entomology. For while it is believed that plants and flowers are modified by the unconscious influence of insects, it is, on the other hand, at least equally certain that the insects will undergo modifications in their turn; and there seems to be some reason to believe that the great and burning question as to the origin of species, or distinct forms of animals and plants, by evolution—that is to say, the modification of organisms under the influence of external causes, assisted by the survival of those best adapted to the prevailing conditions—will finally be fought out upon entomological grounds. In this respect the careful observation and comparison of the insect-faunas of scattered islands of common origin cannot but lead to most interesting results; as may, indeed, be seen from the brilliant researches of Mr. Wallace upon the butterflies of certain islands in the Eastern Archipelago, and from the elaborate investigations of the late Mr. Vernon Wollaston upon the beetles of the Atlantic islands. In the case of the Cape Verde islands the last-mentioned distinguished entomologist, although a staunch anti-evolutionist, was compelled to admit that he did not believe all the closely related permanent forms which he felt himself compelled to describe as species really owed their existence to distinct acts of creation.

One of the most curious phenomena the full recognition of which we owe to the promulgation of the doctrine of evolution is the *mimicry* or imitation by one organism of the general characters of another, or of some inanimate object, instances of which are tolerably numerous. Here again insects hold the first place. The subject was first approached in a philosophical manner by Mr. Bates, who found in the Valley of the Amazon whole groups of butterflies which imitated most closely the form and coloration of other species belonging to quite a distinct sub-family. Mr. Bates discovered that the imitated forms were

endowed with certain properties which rendered them disagreeable to insectivorous birds, and hence concluded that these mimetic resemblances in general were acquired by a process of selection for protective purposes. Many other instances of the same kind have since been detected in various parts of the world, and they are by no means deficient even in this country.

In the preceding rapid and very imperfect sketch I have endeavoured to indicate the more important of the manifold pleasures and advantages which the study of entomology offers to its votaries, even supposing them to pursue it as a mere amusement. But even in connection with this method of study it has been pointed out that certain philosophical notions will crop up, such as the homology of the parts of the mouth in biting and sucking insects, the phenomena of the metamorphoses and of parasitism, the close inter-relation of diverse organisms, and the question of the origin of species. The influence of such studies in training the mind to habits of observation such as involve the clear appreciation of evidence has also been mentioned as a great and important educational advantage.

There is yet another side to the question. In these days of competitive and other examinations, and of wide-spread science-teaching, great numbers of students learn more or less of what is called zoology from lectures and text-books, their object being in most cases, perhaps, only to pass what they call an "exam." By this means a certain amount of morphological knowledge gets crammed into their heads, but of the practical application of this they are as innocent as the babe unborn. For the due comprehension even of the principles of zoology it is essential that the student should possess something more than a mere book-knowledge, often merely of structural details; and an acquaintance with those principles is becoming day by day more necessary, as natural-history considerations are assuming a more and more prominent position in our general philosophy. How is this to be attained? It is manifestly impossible for anyone who does not devote himself entirely to zoological pursuits to make himself practically acquainted with the whole animal kingdom; he must perforce confine his attention more or less to some special group, and extend the knowledge of the principles and method of zoology thus acquired to the formation of a general conception of the whole. I have already indicated that, from the ease with which it is followed, and the total absence of restriction as to locality, the study of entomology presents special advantages; and in other respects, if pursued in no contracted spirit, its influence on the mind of the student will be at least equally beneficial with that of any other branch of natural history.

THE COLLAPSE OF THE ELECTRIC LIGHT.

By W. H. STONE, F.R.C.P.

PLATE V.

IT is hardly matter of surprise that the exaggerated expectations formed a few months ago as to the illuminating power of electricity should have been succeeded by a reaction; and that its practical value, from an estimate that was clearly excessive, should have fallen in public opinion to what is probably an equally unjust depreciation. Nor is it easy to acquit its undiscriminating advocates of ulterior designs, which were to a great extent accomplished in the remarkable, unreasoning, and panic-like depression which occurred in the shares of gas companies. Even if no stockjobbing element intruded itself, there may have been in the excitement a trace of the grim humour so characteristic of Americans, which aims at securing credence for a statement physically impossible by its grave and persistent iteration. It is not many years since the caustic temper of Brother Jonathan was immensely tickled by the universal belief in the older country that the Falls of Niagara had tumbled down; and doubtless he laughed in his sleeve, and chuckled behind a mask of imperturbability, at the pale, anxious faces of gas directors and shareholders. At least one permanent good will have come, at any rate, out of this temporary evil, in the stimulus given to gas-lighting generally, and especially to the urgent need for remedying the discreditable and burglar-encouraging obscurity of our main thoroughfares. "More light, more light," in no metaphorical sense, is now the cry of the English public; and though the tyranny of monopoly, which, in the case of gas, as well as water and drainage, renders the Englishman's house anything but his castle, will probably press heavier than ever, it may at least be hoped that the gas companies, having shown their hands, will for very shame continue to furnish the vastly more perfect system of street-lamps which they have lately inaugurated.

Nothing has conduced to these scientific vicissitudes so much

as the publication of Mr. Edison's specification. This, translated, as is said, from the French, appeared in the "Standard" of Feb. 10, but was rendered comparatively difficult of comprehension by the absence of the figures and diagrams referred to in the text. It was soon followed by a more complete account in the "Engineer" of Feb. 14, from which, by the courtesy of the proprietors, I am enabled to borrow the excellent figures illustrating the present paper (Plate V.). These show the three principal out of no less than forty-eight drawings lodged with the French specification.

Much of his contrivance is of great ingenuity, and evidences considerable mechanical skill. But all competent authorities are agreed in considering that it in no way supersedes existing methods, or that it in any sense fulfils the revolutionising prognostics freely made in its favour. It consists of two parts—1, the means of producing electricity; 2, the lamp.

The electric-magnetic machine is thus described in the specification:—

"It has long been known that if two electro-magnets, or an electro-magnet and a permanent magnet, be drawn apart or caused to pass by each other, electric currents will be set up in the helix of the electro-magnet. It has also been known that vibrating bodies, such as a tuning-fork or a reed, can be kept in vibration by the exercise of but little power. I avail myself of these two known forces and combine them in such a manner as to obtain a powerful electric current by the expenditure of a small mechanical force. In fig. 1 of the drawing a tuning-fork, *a* 2, is represented as firmly attached to a stand, *b* 2. This fork is preferably of two prongs, but only one might be employed, upon the principle of a musical reed. The vibrating bar or fork may be 2 mètres long, more or less, and heavy in proportion. It has its regular rate of vibration, like a tuning-fork, and the mechanism that keeps it in vibration is to move in harmony. A crank and revolving shaft, or other suitable mechanism, may be employed, but I prefer a small air, gas, or water engine, applied to each end of the fork. The cylinder *a* 1 contains a piston and a rod *b* 1, that is connected to the end of the bar, and steam, gas, water, or other fluid under pressure acts within the cylinder, being admitted first to one side of the piston and then the other by a suitable valve; the valve and directing rod *c* 2 are shown for this purpose. The bar of fork *a* 2 may be a permanent magnet or an electro-magnet, or else it is provided with permanent or electro-magnets. I have shown an electro-magnet, *c* 1, upon each prong of the fork—there may be two or more on each—and opposed to these are the cores of the electro-magnets *d*. Hence as the fork is vibrated a current is set up in the helix of each electro-magnet *d* in one direction as the cores approach each other, and

in the opposite direction as they recede. This alternate current is available for electric lights, but if it is desired to convert the current into one of continuity in the same direction a commutator is employed, operated by the vibrations of the fork, to change the circuit connections at each vibration, and thereby make the pulsations continuous on the line of one polarity. A portion of the current thus generated may pass through the helixes of the electro-magnets *c* 1 to intensify the same to the maximum power, and the remainder of the current is employed for any desired electrical operation wherever available. I, however, use the same, especially with my electric lights, but I remark that electricity for such lights may be developed by any suitable apparatus. I have represented commutator springs or levers, *c* 3, *c* 4, operated by rods that slide through the levers *c* 3, *c* 4, and by friction move them. When the prongs *a* 2, *a* 2 are moving from each other the contact of levers *c* 3, *c* 4 will be with the screws 40, 41, and the current will be from line 1 through *c* 1 to *c*, thence to *c* 3 to 41, 43, and to circuit of electro-magnets *d*, *d*, and from *d*, *d* by 42 to 40, *c* 4, and line as indicated by the arrows. When the prongs *a* 2, *a* 2 are vibrating towards each other the circuit will be through *c* 1, *c*, *c* 3, 42, in the reverse direction through the circuit and magnets *d*, *d*, back to 43, and by *c* 4 to line."

Now, the enormous loss of power in a system of magnets in alternating motion will be evident to every student of mechanical laws, as also its inferiority to the simple and regular function of rotation. Moreover, as is well remarked in the "Engineer," the assumption that because a tuning-fork vibrates with small expenditure of power when free, it will do the same when moving in a dense magnetic field, is not only gratuitous but demonstrably false. Many other purely theoretical exceptions may be taken to the machine, such as the bulk of the tuning-fork used, and the impossibility of obtaining from it the necessary rapidity of vibration. It is in the lamp, however, that the principal interest centres, and this is now revealed, as had before been suspected, to depend on the incandescence of platinum or its alloys. The description given of it is as follows:—

"Platinum and other materials that can only be fused at a very high temperature have been employed in electric lights; but there is risk of such light-giving substance melting under the electric energy. This portion of my invention relates to the regulation of the electric current, so as to prevent the same becoming so intense as to injure the incandescent material. The current regulation is primarily effected by the heat itself, and is automatic. In fig. 2 I have shown the light-producing body as a spiral, *a*, connected to the posts *b c*, and within the glass cylinder *g*. This cylinder has a cap, *l*, and stands upon a

base, *m*, and for convenience a column, *n*, and stand, *o*, of any suitable character, may be employed. Most of the other figures are in the form of diagrams, to more clearly represent the electrical connections. I remark that it is preferable to have the light within a case or globe, and that various materials may be employed, such as alum-water, between concentric cylinders, to lessen radiation, retain the heat, and lessen the electric energy required; or coloured or opalescent glass, or solutions that reduce the refrangibility of the light, such as sulphate of quinine, may be employed to moderate the light, and the light may either be in the atmosphere or in a vacuum. The materials that I have found especially adapted to use as light-giving substances are set forth hereafter. The electric circuit, fig. 2, passes by line 1 to the post *r*, and by a wire to the lever *f*, thence by the wire or rod *k*, cap *l*, wire *e*, to the post *c*, through the double spiral, *a*, to the post *b*, and by a metallic connection or wire to the post *n* 1 and line 4, and so on through the electric circuit, and the light be developed in *a*. The rod *k* will expand in proportion to the heat of the coil, or in proportion to the heat developed by the passage of the current through the fine wire *k*; and, if the heat becomes dangerously high, injury to the apparatus is prevented by the expansion of rod *k* moving the lever *f*, to close the circuit at *i*, and short circuit or shunt a portion of the current from the coil *a*, and reducing its temperature. This operation is automatic, and forms the principal feature of my invention, because it effectually preserves the apparatus from injury. The current need not pass through the wire or rod *k*, as the expansion thereof by the radiated heat from the coil *a* will operate the lever *f*, as indicated in fig. 3, but the movement is not so prompt. It is to be understood that in all cases the action of the short circuit or shunt is momentarily to lessen the current through the light-giving substance, and the circuit-closing devices play up and down at the contact point, maintaining uniformity of brilliancy of light."

The use of incandescent substances for producing the electric light was patented as far back as 1841. The contrivance for preventing fusion or softening is neat and ingenious, but far too delicate for the rough purposes of ordinary illumination. Certain appendices to the principal claim, in the form of secondary batteries, hardly require detailed notice, as not touching the main subject of the patent. The ultimate claims may be reduced to the following:—(1) The combination with an electric light of a thermal circuit-regulator, to lessen the electric action in the light when the maximum intensity has been attained. (2) The combination with the electric light of a circuit-closing lever, operated by heat from the electric current or from the light, and a shunt or short circuit to divert the current, or a

portion thereof, from the light. (3) The combination with the electric light of a circuit-closer operated by heat, and serving to place more or less resistance in the circuit. (4) The combination with an electric light of a diaphragm operated by the expansion of a gas or fluid in proportion to the temperature of the light. (5) The combination with a vibrating body similar to a tuning-fork of mechanism for maintaining the vibration, and magnets, cores and helices, whereby a secondary current is set up, so as to convert mechanical motion into electric force or the reverse. (6) The combination with electric lights of means for regulating the electric current in proportion to the heat evolved, so as to prevent injury to the apparatus.

The question, of course, remains whether this, which is the only complete statement yet made, contains the whole of what Mr. Edison has to divulge. It has been somewhat hastily concluded that this is the patent on which he depends. But both the causes named above may conduce to the keeping back of some important matter by way of a surprise. If, however, this be his complete utterance, there is ground for the disappointment very openly expressed in many quarters.

It is remarkable that nothing is said about the subdivision of the current, one of the points most insisted on in the earlier reports of Mr. Edison's contrivances, nor of the mode of measuring the current.

Another recent contrivance for producing light from electricity falls into the same category as Mr. Edison's, owing to its depending on the principle of incandescence—viz., the Sawyer-Man patent—which deserves brief notice in this place. It is produced from a small pencil of carbon placed in a closed chamber, and separated from the conductors by three diaphragms. The conductors are of copper, shaped so as to have great radiating surface, and thus to prevent conduction downwards into the mechanism of the base. The whole is enclosed in a vessel containing nitrogen, with a provision for fixing any residual oxygen. The wasting of the carbon by oxidation is thus prevented. To obviate the danger of crumbling or disintegration of the carbon from sudden heating, an ingenious 'switch,' or current-diverter, is interposed, the mechanism of which is far too complicated for description without diagrams. The greater part of the light is produced by a small part of the current, and in this condition a very small increase materially enlarges the incandescence. The wires supplying the electricity may be conveniently run through existing gas-pipes, each lamp being supplied with a switch placed in the wall, so that by turning a key the light is turned off or on. As long as the house is connected with the main it makes no difference to the producer whether the lights are on or off, since the resistance of the entire

house-circuit must be overcome. A meter records the time each lamp is on. The cost of lamps and switches will not, it is said, exceed that of gas-fixtures. The meter is a clock with an attachment to throw its hands into connection when the light is on. It does not measure the quantity of electricity passing, but only the time the lamp is on.

It is claimed that one horse-power will give by the Sawyer-Man system a light of thirty 5 ft. gas-burners per hour. Where large power is employed the cost of steam, with every item included, is about one cent per horse-power per hour. The cost of 150 feet of gas at New York prices is 41 cents, or fortyfold dearer. Mr. Sawyer, however, does not rest his calculations on price only, on account of the purity and superiority of the illumination.

It would be difficult to furnish, in conclusion, a fair statement of the varied success which has attended the use of this illumination in London. Perhaps the best instance of steady and pleasant dispersion has been in the burners long ago established in front of the Gaiety Theatre, in the Strand, which have of late been supplemented by an additional lamp in the island for foot-passengers in the middle of the roadway. The effect, which, from the straight and level nature of the thoroughfare, is well seen at a considerable distance on either side, is very powerful and agreeable, resembling strong moonlight. On the other hand, the two lamps placed on the Holborn Viaduct have been a failure from the first, and are now to be discontinued, on account of the cost—seven times greater than that of gas. Some technical mistake has evidently been committed here, as the loud puffing of the portable engine in a neighbouring waste space is to any person acquainted with steam-power entirely incommensurable and excessive when compared with the feeble, coloured and flickering beam of the two opal globes. Probably the fault is insufficient and long conductors, with defective insulation.

An excellent trial in a large confined space is that which has been established for the past month at the Albert Hall. Five large lamps are placed in a ring round the centre of the dome, about fifteen or twenty feet below the velarium. At first they were uncovered, and produced the usual unpleasant effect of solid, heavy shadow; but latterly they have been enclosed in a canoe-shaped case of muslin, which seems to diffuse without materially diminishing the radiation. It must, however, be noted that at the concert in honour of the Duke of Connaught's marriage one out of the five went out about half-way through the concert, which lasted two hours and a half, but was subsequently rekindled; and another failed just after this event, and never reappeared through the evening. The effect on entering

the Hall was startling—somewhat like powerful moonlight. The rendering of colour was very remarkable: both the blue sashes in which Mr. Barnby's sopranos and the red in which his contraltos severally invest themselves appearing with unusual brilliancy; while, on the other hand, the tints of the faces and hands seemed to assume a cadaverous and rather ghastly appearance. The general result was not so agreeable as that produced by the fine ring of star gaslights, set in action by an induction-coil, which usually renders the large Colosseum-like interior one of the best and most evenly lighted in the metropolis.

There seems no reason for altering the opinion already expressed in a former article, that the electric light, while invaluable for exceptional cases, such as for lighthouses, military telegraphy, exploring, or for the masthead lights of large vessels in unknown and hostile waters, and even for stage effects and festive occasions, is neither so pleasant, so safe, so steady, so simple, or so manageable as the better forms of ordinary gas-lighting now universally adopted.

The following extract from the 'Times' of the 22nd instant comes most opportunely to corroborate statements made in the above article. W. H. S.

THE ELECTRIC LIGHT IN THE UNITED STATES.

NEW YORK, March 6.

It is now known that Mr. Edison has failed in his experiments. The most that he has ever yet accomplished has been to maintain 400 coiled iron wires in a state of partial incandescence with a 16-horse power steam-engine. The object of this experiment was to ascertain the number of coils which could be brought to a red heat in any given circuit. It is upon this experiment that Mr. Edison based his claim that he could maintain 20,000 lights burning from one electrical station with a 600-horse power engine. The conclusion was a fallacious one, as Mr. Edison now knows. Platinum must be heated to 2,700 degrees before it attains the intensity of incandescence which is required for illumination, and when the metal is as hot as that it is just on the verge of melting. To prevent the lamp from melting, this inventor has used a regulator consisting of a bar of metal through which the current flowed, which, when the current became too strong, expanded and switched off a part of the current, and thus saved the lamp. In practice this regulator has failed to perform the service required of it. When the current becomes strong, the platinum burner melts in the twinkling of an eye, and the mischief is done before the regulator can act. The inventor believed that he could overcome this practical difficulty, but he has not succeeded. His lamps have continually melted, and he has been unable to keep them from doing so, and the result is that there is great discouragement at Menlo Park. There has been another difficulty. Fourteen out of Edison's sixteen applications for a patent at the Washington Patent Office have been rejected. This impulsive man took up

the electric light last fall as an entirely new subject of experiment, and allowed himself to believe that he saw a way to make the light useful which others had never thought of; but when he reached the Patent Office he discovered that very nearly every idea which he had embodied in his applications had either been covered by the patents of other inventors or was not patentable at all. This information is obtained from the Patent Office, and is one explanation of the discouragement which reigns at Menlo Park. There is no doubt that the Edison light would be a delightful resource for the illumination of dwellings, if it could be depended upon. It floods a room as though with golden sunlight pure, brilliant, and mellow. But the inventor has never yet been able to regulate his current so as to keep his lamps burning for any length of time, and he has never ventured on a single public exhibition of it. The public have never seen so much as one of his lights yet. A favoured few who have been admitted to his laboratory at Menlo Park have beheld it—a single lamp, enclosed in a glass globe, beautiful as the light of the morning star. But he has refused to let anyone inspect it closely, and has never allowed the exhibition of it privately to last long. He has never been able to depend upon its durability. His apparatus is as far from perfection as it ever was; and, in fact, well-informed electricians in New York do not now believe that Mr. Edison is even on the right line of experiment.

EXPLANATION OF PLATE V.

FIG. 1. Dynamo-electric machine, worked by means of a tuning-fork.

„ 2. Upper portion of the lamp, showing, *a*, the spiral of platinum connected with the terminals, *b* and *c*, and enclosing *d*, the metal rod, which by expansion diverts the current, and prevents fusion of the incandescent wire.

„ 3. Detached figure of the shunting apparatus.

THE FERÆ NATURÆ OF THE LONDON PARKS.

By J. E. HARTING, F.L.S., F.Z.S.

THE extent and variety of animal life which may be found existing in the parks and gardens of London, notwithstanding the co-existence of many unfavourable conditions, is very remarkable, and furnishes a curious illustration of that "struggle for existence" which is being perpetually carried on, not by man alone, but by all living things.

In the midst of so densely populated a city as ours, where the vegetation of the open spaces is being constantly trodden under foot, or struggles upward with difficulty through an atmosphere of smoke and sulphur, it would hardly be supposed that any wild creature—unless the rook and the ubiquitous sparrow may be so termed and excepted—could find either sufficient food or sufficient freedom from molestation to enable their existence. The inquisitive naturalist, however, well knows that the case is otherwise.

It is, of course, many years since any of the larger *feræ naturæ* were to be found in the London parks, although many persons still living must remember the deer in Hyde Park; and may have had pointed out to them the places where the last otter was speared, and the last hare killed.

Before considering the attractions which the parks at present afford to the naturalist, it may be not uninteresting to glance briefly at their former condition. When, in exchange for the priory of Hurley, in Berkshire, Henry the Eighth, in 1536, acquired from the monks of Westminster the manor of Hyde, the park, of larger dimensions than we now see it, was fenced in for the greater protection of the deer which were preserved there, and frequently hunted. In that year a royal proclamation was issued, in which it was stated that "as the King's most Royal Majesty is desirous to have the games of hare, partridge, pheasant, and heron preserved in and about the manor of his palace at Westminster, for his own disport and pastime, no person, on the pain of imprisonment of their bodies, and further punishment at his Majesty's will and pleasure, is to presume to hunt or hawk from the palace of Westminster to St. Giles' in

the Fields, and from thence to Islington, to our Lady of the Oak, to Highgate, to Hornsey Park, and to Hampstead Heath."

In several succeeding reigns Hyde Park served as a royal hunting-ground. Edward the Sixth, while yet a boy, hunted there in 1550 with the French Ambassadors. In 1578, when John Casimir, Duke of Bavaria, paid a visit to Queen Elizabeth, he stayed at Somerset House, and amused himself with hunting at Hampton Court, and shooting in Hyde Park, where it is recorded that in February of that year "he killed a barren doe with his pece from amongst ccc other deere." *

The Queen herself used evidently to witness the sport, if she did not actually take part in it, as she did elsewhere,† for in the accounts of the Board of Works for the year 1582 is an entry of a payment "for making of two new standings in Marybone and Hyde Park for the Queen's Majesty and the noblemen of France to see the hunting." It is to these, probably, that Norden, the topographer, alludes when describing the place about this time. He writes: "Hyde Park, substantially impayled, with a fayre lodge, and princelye standes therein. It is a stately parke, and full of fayre game."‡

James the First continued to preserve the game here with great strictness; and in October 1619 some deer-stealers were executed at Hyde Park Gate, and with them a poor labourer, whom they had hired for 1*s.* 4*d.* to hold their dogs.§

In January 1625, a warrant was sent to the keeper of Hyde Park to cause three brace of bucks to be taken to Marybone Park, to supply the scarcity caused by the great rain there; and another warrant to the master of the toils, for the toils to be sent to Hyde Park for the purpose.‖

St. James's Park, which, prior to the time of Henry the Eighth, was little better than a marshy field, was in his reign enclosed and stocked with deer.

There were no less than eleven ponds there in James the First's time. These were turned to account by being stocked with fish and waterfowl, and the park was then much improved and ornamented with walks and fountains. The part of the park now called the Enclosure was staked off from the walks by Charles the Second for the purpose of protecting the deer and other animals of which he was very fond.

The collection of waterfowl maintained by Charles the Second in St. James's Park must be familiar to all who have read the

* Lodge's "Illustrations of British History," 1791, vol. ii. p. 205.

† Letter from Rowland White to Sir Robert Sidney, dated September 12, 1600; and Nichols' "Progresses, &c., of Queen Elizabeth," vol. iii. p. 90.

‡ Norden, "Survey of Middlesex and Hertfordshire," 1596, p. 19.

§ Calendar of State Papers, Domestic Series, 1619–23, p. 88.

‖ Ibid., 1623–25, p. 446.

diverting pages of Evelyn and Pepys. The park at this time, says Evelyn, was "stored with numerous flocks of several sorts of ordinary and extraordinary wild-fowl, breeding about the decoy, which, for being so near a city, and among such a concourse of soldiers and people, is a singular and diverting thing." *

In William the Third's time a proclamation was issued for the preservation of game "within ten miles of the Court of Whitehall and the precincts thereof." This proclamation, which was published in the "London Gazette," in October 1690, forbade the keeping of "a fowling-piece, gun, setting dog, net, trammel, or other unlawful engine," by any person "other than such as shall be by law qualified;" and such as gave information concerning offenders to John Webbe, living in St. James's Park, were to be rewarded.

Grosley, in his "Tour to London," 1772, especially notices the deer in St. James's Park, and remarks that "in that part nearest Westminster nature appears in all its rustic simplicity —a meadow regularly intersected and watered by canals, and with willows and poplars without any regard to order."

Deer were to be seen in Kensington Gardens for some time after the commencement of the present century, and remained in Hyde Park until the year of the Queen's coronation when, a great fair being held there for some days, they were removed to Bushey, and never replaced.

The last wolf is thought to have been killed in England during the reign of Henry the Seventh, at which period this animal had become so extremely scarce as to be confined to a few of the wilder and more remote districts in the North of England.†

Its extinction in the neighbourhood of London dates some centuries earlier, and we are happily unable to include it in our present list. But there is a story on record of a wolf at large in St. James's Park, which may be appropriately quoted here.

In 1739, near the Vineyard, in St. James's Park, lived a gentleman who kept a wolf. One night in January in that year the animal broke loose and found its way into the park. The first human being he saw, early in the morning, was a milkman, at whom he flew furiously. The man set down his pails and took to his heels; and as the milk was apparently more tempting to the wolf than the milkman, he began at once to drink it, during which time the man escaped. The animal having thus refreshed himself, and espying a calf at a little distance, immediately killed and partly devoured it; but fortunately while thus engaged he was found by his keeper and recaptured before he could do any further mischief.‡

* Evelyn's Diary, February 9, 1664–5.

† See "Pop. Sci. Review," 1878, p. 150.

‡ Larwood, "London Parks," vol. ii. pp. 175–6.

The fox as a lurker in the London parks survived to a comparatively recent date. So late as the end of the last century a good many were still to be found in Hyde Park, and the Ranger used to carry a gun in his walks for the purpose of shooting them whenever he had a chance. There is extant a minute of the Board of Green Cloth, dated in 1798, granting a pension of 18*l.* to Sarah Gray, in compensation for the loss of her husband, who had been accidentally shot by one of the keepers whilst they were hunting for foxes in Kensington Gardens.* These animals were but the natural attendants upon the hares and pheasants which existed in the parks at that date. When game was no longer preserved there, and henroosts were not at hand, the foxes must have left their quarters there, or starved. The Ranger's gun probably hastened their extinction by a few years only.

So long as the parks were on the outskirts of London so long was there a chance of accession to the number of *feræ naturæ* within their precincts from the country beyond; but so soon as houses crept up to and surrounded the parks, and the latter became more and more resorted to by the public, the impossibility of preserving the game became apparent, and the attempt was abandoned.

A curious hare hunt took place in Hyde Park in October 1809, and resulted in the death of what was, perhaps, the last hare killed in that park. At that time, and for many years afterwards, there were only a few detached houses north of the Uxbridge Road, an alehouse or two by the roadside, and, farther on, two little hamlets in the midst of the fields—viz., Craven Hill and Westbourne Green—for Paddington was then limited to a row of houses along the Edgware Road. A hare having found her way into Hyde Park from the adjoining country, was suddenly discovered on the open space between the Barracks and the Serpentine; and as soon as she was started all ranks joined in the chase. Poor Puss, finding retreat impossible, took to the Serpentine and swam rapidly across. But the alarm having spread to the other side, before she could land numbers were waiting ready to receive her. At length, being afraid to attempt a landing, and almost exhausted by terror and fatigue, she seemed to be drowning, when a boy jumped into the water and seized her. A gentleman immediately released her from her pain by killing her, and, giving the boy a crown, carried away the prize.

For some years after this, the Regent's Park—then private royal property—held plenty of hares, and between 1824–28 coursing matches used to be held there.

The marshy pools in Hyde Park which once occupied the site

* Smith, "Historical Recollections of Hyde Park," 1836, p. 30.

of the Serpentine, and afforded sanctuary to the herons which Henry the Eighth was at such pains to protect, were at one time the haunt of otters. These animals would find their way up the two small streams which entered London from the west and north-west, viz., the West Bourne and the Eye Bourne (Tyburn); and, remaining concealed by day, would find their food at night amongst the coarse fish which tenanted the pools. But when, in 1730, all the ponds were united into the handsome piece of water called the Serpentine, the streams covered in, and the ground cleared and made more ornamental, the home of the otter was destroyed. For some years afterwards, however, a stray one seems now and then to have reappeared, but only to meet with that reception from a crowd which, prompted by thoughtlessness and inhumanity, is usually accorded to strange animals.

During the summer of 1739 a large dog otter took up its abode in St. James's Park, and there made free with his Majesty's fish. For a long time it escaped all the gins and snares laid for it; but at length its death being resolved on, a regular otter-hunt was organised, at the desire of the Earl of Essex, who was then Ranger, and Sir Robert Walpole's pack of otter-hounds was borrowed for the occasion. The otter had taken shelter on Duck Island, but was soon driven into the moat, and was closely pressed by the hounds at his frequent "venting," though sometimes he dived half the length of the canal which surrounded Duck Island. After a long chase he left the water, and attempted to run to the great canal, but before he reached it he was speared by Mr. Smith, the huntsman of the pack. This unprecedented otter-hunt took place in the presence of his Royal Highness the Duke of Cumberland, the Earl of Essex, and several other noblemen, who, armed with spears, all took an active part in the sport. According to the papers of the day, the animal measured five feet in length.

But although so many years have elapsed since this incident occurred, it is by no means the latest date at which the otter has been met with in the neighbourhood of London, if not actually in a London park. In March 1829 a young otter, about eight months old, was killed at Kilburn in a field which is now the site of the railway station. In the autumn of 1831 an otter haunted the Brent, where the head of Kingsbury Reservoir now is. The reservoir was not then formed, and at that particular spot was a famous bed of flags, well calculated to afford shelter to such an animal. About the end of September or beginning of October in that year this animal was shot. A third otter was seen for several months during the latter part of 1847 about the brook between Hendon and Edgware, and was several times hunted by the harriers of Mr. Dancer, of Kenton, but never killed. A fourth, which was described as a very fine

large animal, was observed early one morning, by a policeman on duty, crossing the park belonging to Lord Mansfield, at Hampstead, and making for the water. It was subsequently seen by several other persons, some of whom, known to the writer, laid in wait to try and shoot it, but without success. This was in the spring of 1855.

But perhaps the most extraordinary capture of an otter in London was that which was made in 1863. On March 25, in that year, as a coachman was proceeding at daybreak along Aberdeen Place, leading from Maida Hill to St. John's Wood, he observed an otter trotting along close to the wall, and overtaking it, succeeded by repeated kicks with his heavy boots in killing it. It was then taken to Mr. Gardner, of Holborn, for preservation, where the writer saw it on the following day. It was a young animal, of very moderate dimensions; and if it had not escaped from confinement, its appearance in such a place can only be accounted for by supposing that it had come up the Canal to Maida Hill; and being unwilling to keep to the water through the tunnel, was following its course above ground, and if unmolested would probably have entered the Canal again in the Regent's Park.

It is doubtful whether the squirrel was ever an inhabitant of the London parks, no record of its appearance there being extant, although, from its having been met with in the woods of Hampstead, Highgate, and Hornsey, it is not unlikely that it was at one time common enough on the north side of London. In all probability the park trees, although affording shelter enough to screen these little animals from observation, would not supply sufficient food suited to their requirements.

During the long summer evenings, bats may not unfrequently be observed on the wing, not only in the parks, but even in the London streets. At least four species have been identified, conspicuous amongst which is the great noctule—the *Vespertilio altivolans* of Gilbert White—which has frequently been observed in Kensington Gardens. We have on several occasions seen the pipistrelle on the wing in Oxford Street—sometimes quite early in the afternoon; and we once examined a specimen of Natterer's bat which was caught in Thayer Street, Manchester Square. The fourth species referred to is the long-eared bat, which, next to the pipistrelle, is perhaps the commonest species of all.

From the present aspect and condition of the parks it is evident, as might be expected, that the majority of the existing *feræ naturæ* belong to the feathered rather than to the four-footed tribes; and the number of birds, both resident and migratory, which may be detected there by a good observer is not a little remarkable.

Although the days have long since gone by when kites used

to carry off the offal from the streets of London, and build their nests in Hyde Park and in the clumps of trees in Gray's Inn, one of these birds was observed no longer ago than 1859 passing over Piccadilly.* Almost the only birds of prey still to be seen occasionally about London are sparrow-hawks and kestrels. The former are sometimes taken in the act of dashing at cage-birds when hung up near a window, three or four such instances having come to the writer's knowledge. In April, 1871 a pair of kestrels had a nest in the cable attached to the anchor of the naval hero on the summit of the column in Trafalgar Square.

We have more than once observed a peregrine falcon passing over London, where, there is reason to believe, these birds occasionally make a temporary stay, frequenting the church-tops and roofs of public buildings, attracted no doubt by the pigeons, which furnish them with many a meal. A pair for many years frequented the top of St. Paul's, where it was supposed they had a nest. When the royal hawks were kept at the Mews, at Charing Cross, the "eyess" falcons were probably "flown at hack" in Hyde Park, but on this point no contemporary writer gives any information.†

Aubrey gives an anecdote related to him by Sir Edward Sherborne, of a sparrow-hawk belonging to Charles the Second. "Not long before the death of that king," he says, "a sparrow-hawk escaped from the perch, and pitched on one of the iron crowns of the White Tower, and entangling its leash in the crown, hung by the heels and died. Not long after, another hawk pitched on one of the crowns." This anecdote is given under the head of "Omens." ‡

Perhaps the most ancient birds now in London are the rooks, numerous colonies of which exist, not only in the parks, but in other open spaces, and even in the gardens of private houses. The history of these rookeries has lately been furnished in a very entertaining article by Dr. Edward Hamilton,§ since which some additional details have been published by Professor Newton.‖

The history of the rookery in the Temple Gardens is rather curious. It is said to have been founded in Queen Anne's time

* See "The Zoologist," 1859, p. 6676.

† The royal hawks were kept at Charing Cross during many reigns (according to Stow, from the time of Richard II., in 1377), but they were removed by Henry VIII., who converted the Mews into stables. The name, however, confirmed by the usage of so long a period, remained to the building, although after the hawks were withdrawn it became inapplicable. But what is more curious, in more modern times, when the people of London began to build ranges of stabling at the back of their streets and houses, they christened those places "mews," after the old stabling at Charing Cross.

‡ Aubrey's "Miscellanies," 1696. (Ed. 1784, p. 59.)

§ See "The Zoologist," 1878, pp. 193–199.

‖ "The Zoologist," 1878, pp. 441–444; and Yarrell's "History of British Birds" (4th ed.), vol. ii. p. 290.

by Sir William Northey, who colonized the place with birds from his estate at Epsom. A bough was cut from a tree with a nest containing two young rooks and taken in an open waggon from Epsom to the Temple, and fixed to a tree in the gardens. The old birds followed their young and fed them, and they remained and bred there. The following year a magpie built her nest in the gardens: her eggs were taken and those of a rook substituted, and in due course were hatched there.*

That magpies formerly nested in St. James's Park we learn from a story which has been preserved to us from Charles the First's time in connection with one of these birds. Amongst the numerous Frenchmen who flocked to this country in 1638 in the wake of Queen Henrietta Maria was a certain M. Souscarrière, who although a notorious cheat and gambler, had contrived to insinuate himself into good society and came to London to recruit the health of his purse. He brought tennis-players, lute-players, and singers with him, as he said, to amuse the natives, and ere long gained large sums of money by gambling. On one occasion, however, he was cleverly overreached. For a long time he secretly practised to throw a tennis-ball into the nest of a magpie in one of the trees in St. James's Park; and when he saw that he could manage it, he took a heavy bet with some unsuspecting gentleman that he would lodge a ball in the nest in a certain number of throws. Unfortunately for Souscarrière he had been observed practising this trick by another gentleman, who, the day before the bet came off, filled the nest with moss, so that the ball could not roll into it, and the Frenchman lost his wager, to the great amusement of all who were in the secret.†

The carrion crow is occasionally observed in the London parks; and we have more than once seen the hooded or grey crow, in winter, in the Regent's Park—generally engaged in robbing the ducks of their food. On the 8th and 9th of November, 1874, a hooded crow was seen feeding on the lawn of the Inner Temple Gardens. It flew from tree to tree, occasionally dropping on to the grass, and was apparently not at all scared by the crowds of people assembled on the Thames Embankment to see the Lord Mayor on his return from Westminster.

The jackdaw makes himself at home in Kensington Gardens and Holland Park, living in holes in some of the old trees, and making excursions in all directions. His presence may often be detected when flying homeward with the rooks by his smaller size and sharper cry.

* This account was communicated to the writer by a son of the late Mr. Everest, who, in conjunction with Mr. Pownall, published, anonymously, in 1825, a History of Epsom.

† Larwood, "London Parks," vol. ii. p. 77.

Amongst the old trees in Kensington Gardens both the greater and lesser spotted woodpeckers may be occasionally seen; the latter being the commoner bird of the two, although the former has been known to breed there. Both species have been noticed also in the Regent's Park.

To give any detailed account of the numerous small birds which have been observed to frequent the London parks and gardens at different seasons would carry us far beyond the limits of the present article.* It must suffice if we refer briefly to some only of the more noteworthy.

Amongst these the nightingale should, perhaps, stand first. Several naturalists have detected its presence in summer in the Regent's Park; and of late years a favourite resort of this bird has been the Flower Walk, in Kensington Gardens, whence its unmistakable notes have been poured forth in April and May to numbers of delighted listeners. Skylarks sometimes visit Hyde Park, where we have occasionally both seen and heard them.

Few would expect to find in the great metropolis so sylvan a species as the cuckoo, and yet this bird not only passes through town on its way to and from its summer quarters, but occasionally stays long enough to commit an egg to the care of some dupe of a foster-parent. In August 1870 we observed a cuckoo in Lincoln's Inn Fields; and in August 1876, while passing from Bedford Row to Gray's Inn Square, we saw a cuckoo fly across Gray's Inn Gardens and pass over Holborn in a southerly direction. It was flying so low that it only just cleared the tops of the houses. An observant friend, who pays frequent visits in the early morning to the Botanical Gardens, Regent's Park, discovered that the reed warbler breeds there every summer; and in the nest of one of these birds, in 1872, he found the egg of a cuckoo. The following summer he was much interested in observing a young cuckoo sitting in the centre of a growth of large heracleums and being fed with caterpillars by a reed warbler. At the lake in the same gardens the kingfisher is sometimes seen, generally in autumn, and occasionally makes a protracted stay. In August 1863 a kingfisher was seen frequently at the Ornamental Water in the Regent's Park.

Amongst the few observations of Gilbert White which relate to birds in London is one which has reference to the house-martin. He says: 'I have not only seen them nesting in the

* In the "Proceedings of the Zoological Society" for 1863 (p. 159) will be found a list, by Mr. Bartlett, of no less than fifty-seven species of birds observed by him in the Regent's Park; and Mr. F. D. Power, in the "Zoologist" for 1865 (p. 9727), has furnished another list of twenty-four species which he noted as having occurred in a single square in London—Queen's Square, Bloomsbury. A resident of Gray's Inn in the course of ten years found that twenty different kinds of birds had been seen there by him. See "The Field," March 11, 1876.

Borough, but even in the Strand and Fleet Street; but then it was obvious, from the dinginess of their aspect, that their feathers partook of the filth of that sooty atmosphere.' * Further on he says: 'In London a party of swifts frequents the Tower, playing and feeding over the river, just below the bridge; others haunt some of the churches of the Borough next the fields, but do not venture, like the house-martin, into the close, crowded part of the town.' †

A pair of ring-doves nested for many years in an old tree in the Green Park, where they were last observed in 1877.

Early in July 1873 an immense flock of swifts was observed passing over Hyde Park to the westward, at a height of about a hundred yards from the ground. It was estimated that there must have been 1,500 or 2,000 of them—a most unusual congregation for this species.

Did space permit we might give particulars of the appearance of many uncommon birds (that is, uncommon for London) which have alighted at various times in different parts of the metropolis, and amongst which we should have to name the partridge, quail, snipe, woodcock, and stork.

Snipe and woodcock have frequently been picked up, and almost invariably in the vicinity of telegraph-wires, against which they must have flown when passing over the city at night. General Oglethorpe, who died in 1785, and who was considered the best shot of his day at birds on the wing, frequently killed woodcocks, in company with his friend Carew Mildmay, on the ground where Conduit Street now stands.

During severe weather strange wildfowl, such as pochards, scaups, and coots, occasionally alight upon the lakes in the London parks; and now and then a diver makes its appearance. We have observed the little grebe upon the Round Pond, in Kensington Gardens; and were not a little surprised one summer to find this bird nesting there, the nest, a floating, shallow structure, being moored to some aquatic plants at a distance from the shore.

At the periods of migration in spring and autumn gulls and terns occasionally visit the Serpentine, and never fail to attract attention, from the contrast which their snow-white plumage presents with the surrounding landscape.

To see all these and many other birds which we have not named the observer should be astir early, ere the noise and traffic of a busy day drives them to concealment, or, it may be, to leave the neighbourhood. In these morning walks in town it is curious how the eye and ear may be gladdened with rural sights and sounds which few would expect to meet with in the heart of a great city.

* Letter XVI., to Daines Barrington.

REVIEWS.

THE STUDY OF ROCKS.*

THIS book well supplies a want long felt by students of Petrology in this country. Several valuable text-books on the subject have within the last few years been published on the Continent, but Mr. Rutley's volume is the first purporting to afford elementary instruction on the study of rocks by the aid of the microscope, which has appeared in the English language.

The work is divided into two parts—Rudiments of Petrology, and Descriptive Petrology.

Beginning with a chapter on methods of petrological research, the author proceeds to consider the origin of rock-masses and of the various disturbances to which the earth's crust has been subjected, as well as the general characters and modes of occurrence both of eruptive and sedimentary rocks.

A minute description is given of the appliances and methods employed for the preparation of sections suitable for microscopical examination, as well as of the microscope and accessories best suited for this class of investigation. A chapter follows on the examination of the optical characters of thin sections of minerals; and the first division of the work terminates with a lucid description of the principal rock-forming minerals, including both their megascopic and microscopic characters.

The second division, which is devoted to a description and classification of the various eruptive and sedimentary rocks, affords evidence of much careful consideration, and furnishes a fair epitome of the present state of our knowledge of this subject.

The text is illustrated by a large number of woodcuts, which, although not elaborate, are always clear and effective. A few slight oversights of a kind incident to all first editions have been observed, but the book is generally characterised by clearness and accuracy. It will therefore be welcomed by all who may wish to acquire a competent knowledge of Petrology, but more particularly by those unacquainted with German and French, in which languages all previously available works on this subject have been written.

From its somewhat limited extent, certain subjects have of necessity received but small attention, although nothing of importance appears to have been omitted. We therefore heartily recommend Mr. Rutley's volume

* "The Study of Rocks, an Elementary Text-book of Petrology." By Frank Rutley, Esq., F.G.S., H.M. Geological Survey. London: Longmans, 1879.

to the student of Petrology, who, as the author himself remarks, must bear in mind that he cannot become acquainted with this subject by reading alone, and that the work before him does not pretend to be more than a systematic rudimentary guide.

WATTS'S DICTIONARY OF CHEMISTRY.—THIRD SUPPLEMENT.*

THE present Supplement brings the general Record of Chemical Discovery down to the end of the year 1877, and includes some of the more important discoveries of 1878. As, however, it comprises an unusually long interval of time, it has been found necessary, in consequence of its large size, to publish it in Two Parts.

The author acknowledges his obligations to Professor E. J. Mills, F.R.S., for an article on Cumulative Resolution; to Professor J. E. Thorpe, F.R.S., for one on Flame; and to Mr. R. Warrington, F.C.S., for articles on Forest-trees and on Barley.

Among the more important articles on Inorganic Chemistry are those on Alum, Anorthite, Antimony, Arsenic, Barium, Bismuth, Boron, Borates, Cadmium, Cæsium and Rubidium, Cerite Metals, Chlorine, Chromium, Chrysocolla, Clays, Cobalt, Copper and its Alloys, Corundum, Didymium, Enstatite, and Felspars.

The portion relating to Organic Chemistry comprehends articles on Acetamide, Acetic Acid, Ammonia derivatives of Acetone, Acrolein, Amyl, Alcohols, Anthracine, Alizarin, Benzamide, Benzine, Benzoic Acid, Butyl Alcohols and Ethers, Chrysoidine, Cinchona, Cinchonine Group, Citric Acid, Cumene, Cyanamide Cyanates, Cymene, Diamenes, Diconic Acid, Dye Stuffs, Ethers, and Fermentation.

The article on Arsenic comprehends a list of the sulphur-salts of that metal which are produced when hydrosulphides are saturated with arsenic pentasulphide. Under the heading of Copper, the Hunt and Douglas process for the wet extraction of that metal from its ores is described, as well as the employment of phosphorus in the process of copper-refining.

The methods used by Hautfeuille for the production of artificial crystals of orthoclases and albite are given under the head of Felspar, as well as a large number of recent analyses of the different members of this important mineral group. The views of Tschermak and Vom Rath on the one hand, and those of Descloizeaux and Petersen on the other, relative to the constitution of the triclinic felspars, are concisely and clearly stated; and this article may be regarded as affording a lucid summary of the present state of our knowledge on this subject.

The articles on Organic Chemistry have been prepared with the care and exhaustiveness for which Mr. Watts is so distinguished; while Mr. Warrington's article, of twenty-five pages, on Forest-trees is a valuable monograph on that important and interesting subject.

* "A Dictionary of Chemistry and the Allied Branches of other Sciences." By Henry Watts, B.A., F.R.S., &c. Third Supplement, Part I. London: Longmans, 1879.

ANIMAL MORPHOLOGY.*

SOME three years ago Prof. Macalister, of Dublin, published what was intended to be the first part of an introduction to the Morphology of Animals, in which he treated of the Invertebrata. The second part, relating to the Vertebrates, is now published, but as an independent work, forming part of the "Dublin University Press Series." It is, we think, to be regretted that this sort of separation should have been made between what ought to have been the two volumes of one book, but we presume that financial considerations have had some influence in leading to the adoption of such a course, and if so, we must not quarrel with the author on this account.

Professor Macalister's present volume, like the former one, is literally an introduction to the morphology and broader classification of the animals of which it treats; the habits of the animals, their geographical distribution, and other matters relating to their natural history, are almost wholly unnoticed, and thus the book, whilst admirably fitted for a student's text-book, will prove disappointing to anyone who mistakes it for a general treatise on zoology.

It is, however, as a student's text-book that the author intends his book to serve, and its *raison d'être* is explained in the following passage from his preface, in which he justifies the use of the word "Introduction" in its title, at which, it seems, some reviewers have cavilled. "I remember when a student," he says, "that I found the gap between most manuals then existing and the monographic literature of zoology to be so great, that, passing from the first to the second was practically entering an unknown region; and hence in this work I have tried to make each part sufficiently comprehensive to enable the student, who wishes for additional knowledge of any forms, to pass from a general study of morphology into the region of detail, without any great intermediate gap."

This quotation sufficiently explains the object Prof. Macalister had in view in writing this book, and in most respects he has well fulfilled it. Starting with a short statement of the general characters common to all vertebrate animals, he next indicates the characteristics of the two primary groups, Acrania and Craniota, the former now represented only by that singular creature the *Amphioxus*; and then proceeds to describe the structural modifications exhibited by the classes, orders, and subordinate groups recognised by the most recent writers on the different sections of vertebrates. The classification is carried as far as the families, of which, however, very brief characters are given.

Throughout, so far as we can judge, Prof. Macalister has given an excellent summary of the structural characters of all the great groups of vertebrate animals, including in all cases the history of the development of the embryos, which occupies so important a place in all recent morphological work. The special groups founded for the reception of fossil forms are also described in connection with those including their existing allies.

As a matter of course it would be easy to raise objections to some parts of

* An Introduction to the Systematic Zoology and Morphology of Vertebrate Animals. By Alexander Macalister, M.D., &c. 8vo. Dublin: Hughes, Foster, and Figgis. London: Longmans. 1878.

the classification adopted by our author, which, as already indicated, is founded upon the views put forward by the latest writers upon the different groups. But in a case to which the old proverb "so many men, so many minds" is peculiarly applicable, to insist upon such objections would be absurd. For our own part, we cannot help regarding the establishment of eighteen orders of birds as unnecessary, and as masking absolute relationships; but the author has the authority of Prof. Huxley and others on his side, and must not be blamed for adopting what is really the result of the analytical method of studying zoology now prevalent, and due to the fact that the leading students of that science have been for years becoming more and more pure anatomists and less zoologists in the broad sense of the term. To the same circumstance it is owing that Prof. Macalister's work bristles with technical terms in every line, a characteristic which was animadverted upon rather severely, in connexion with his former volume. The fact is, however, that the Professor is hardly the guilty party in this instance. He found the terms in use, proposed by men whose names bear authority, and he is perhaps rather to be praised than blamed for having used and explained them for the benefit of his readers. The fault lies with the inventors of such a multitude of terms, who seem to forget, in the desire to introduce the greatest possible precision into their descriptions of the structure of a given group, that there are hundreds of other groups equally deserving of being treated in a similar fashion, and which, being actually so treated, give rise to a terminology of the most fearful extent and difficulty. If matters go on long in the present fashion we shall have to learn a new technical language for every group of animals. The thing has already gone to a very considerable length, and as Prof. Macalister has clearly defined most of these modern morphological terms of art, his use of them in the present book will be of advantage to those who really wish to master the study of animal morphology.

In this, as in his former volume, the author has adopted the plan of printing details in small type. It is illustrated with a few woodcut figures and diagrams, which aid greatly in elucidating some of the more obscure points to which the author has to refer; and a tolerably copious Index, generally containing references to the definitions of technical terms, adds considerably to the value of the volume, which may be recommended as a very useful guide for the practical student.

THE ZOOLOGY OF VICTORIA.*

BESIDES publishing the results of the geological and botanical investigations of the colony which have now been in progress for a good many years, the Government of Victoria seem resolved to do what they can for the elucidation of its zoology, and accordingly Prof. McCoy has just brought out the first part of a work on this subject which promises to be of great interest and value. From his preface it appears that, with the view of

* "Natural History of Victoria. Prodromus of the Zoology of Victoria; or, Figures and Descriptions of Living Species of all Classes of the Victorian Indigenous Animals." Decade I. By Frederick McCoy. 8vo. Melbourne. London: Trübner & Co., and G. Robertson. 1878.

securing accurate representations of those animals which readily undergo important changes after death, even when preserved in spirit, many drawings and descriptions have been made from fresh or living specimens as opportunities occurred; and from these and other materials it is proposed to publish from time to time "decades" of plates, with descriptive letterpress, but in no particular order, to be supplemented by a final systematic volume for each class so soon as the investigation of its members inhabiting the region can be approximately completed.

The first of these decades is now before us, and we must congratulate Prof. McCoy upon the commencement of what will evidently be a work of great importance, not only in the colony, but to naturalists in all parts of the world. Poisonous snakes are so rife in Australia, and the means of distinguishing them a matter of so much interest to the colonists, that we do not wonder to find the first three plates in this decade occupied by species of Elapidæ, which appear to rival their dreaded relative, the Indian cobra, in the virulence of their venom. Three more plates are devoted to marine fishes, namely, a sea bream (*Chrysophrys australis*) and two fine species of gurnards. One of the latter (*Lepidotrigla vanessa*), here correctly figured for the first time, is very beautifully coloured. The seventh plate represents a "giant earthworm" (*Megascolides australis*), which is said to reach a length of six feet when extended to the utmost. It agrees in its general character and habits with the species with which we are sufficiently familiar in this country. On the eighth plate we find representations of three species of moths of the genus *Agarista*, in all stages of growth. These figures are of special importance in the colony, as one of these moths, although a native of Australia, has taken to feed on the introduced grape-vines with such avidity as to cause very considerable damage. Plates 9 and 10 show two butterflies of the genus *Pieris*, with their transformations. Full descriptions of all the species are given, accompanied by a few remarks on the natural history of the animals.

Of the plates we must speak in high terms of praise. The figures of the animals are well drawn, and printed in colours in a style which may well excite our wonder that such work can be turned out in a place which was a howling wilderness not fifty years ago. Each plate bears, besides the principal figure or figures, representations in outline or otherwise of those details which are of most importance for the determination of the species, and altogether Prof. McCoy and his assistants have evidently done their best to make the work a most valuable one. That they have been remarkably successful so far we need hardly say, but it is a question whether any of us will live to witness the completion of the work, if the entire Fauna of Victoria is to be illustrated in a similar fashion.

PRACTICAL GEOLOGY.*

UNDER the title of "Practical Geology," Mr. Harrison has added another work to the list of smaller manuals of geological science, one of the

* "Practical Geology." By W. J. Harrison, F.G.S. Sm. 8vo. London: W. Stewart & Co. 1878.

objects of which is to show the reader how to see for himself the leading facts of geology. With this view the author in the first three chapters gives the preparation for the study, the kind of apparatus required, the mode of investigation in the field, and the method of determination of rocks, assisted by their microscopical examination. After noticing the nature of the oldest rocks, the formations, from the Cambrian to the Recent period, are successively described. Each chapter is complete in itself, and contains a clear and readable description of the occurrence, lithological structure, divisions, and principal life-forms of the strata noticed, together with brief allusions to their economic bearings and effects upon scenery. Throughout, the subject-matter is concisely treated, and this little manual will form a serviceable guide to the geological classes for whom it was more especially intended. Some slight corrections may be found necessary; and the illustrations would have been more instructive if they had been more carefully executed.

THE "CHALLENGER'S" VOYAGE.*

AT the first glance we were inclined to say of this book, "Here is another unsatisfactory outcome of the voyage of the 'Challenger,'" the first chapter or two seemed so tame and *jejune*. On reading further, however, it appeared that this was due, in part at any rate, to the fact that the wind had been taken out of Mr. Moseley's sails by Sir Wyville Thomson's prior publication, relating to the voyage in the Atlantic, and perhaps in part to the fact that the author had not got thoroughly warmed up to his work, for he tells us in his preface that the greater part of his narrative was written n board the ship, and "sent home from the various parts touched at, in the form of a journal." Later on, indeed immediately after the departure from the West Indies, the author apparently takes a fresh start, and the remainder of his book is so good that, although we cannot quite endorse the opinion of some critics who place it on a level with the admirable "Journal of Researches" of Charles Darwin, it may certainly be characterised as one of the best records of scientific travel that we possess.

Leaving the details of the dredgings and deep-sea soundings which constituted the principal business of the "Challenger's" voyage to other hands for description, Mr. Moseley records the general incidents of the voyage, and his impressions of the localities visited, but intersperses these with many exceedingly interesting and valuable observations on various subjects of natural history. Among these scientific notes marine objects, of course, occupy a considerable space, but the author's remarks relate to a greater extent to the productions of the land, and as the ship in the course of her four years' wanderings touched at a great number of out-of-the-way places, Mr. Moseley has been enabled to make many valuable additions to our stock of natural history information.

* "Notes by a Naturalist on the 'Challenger': being an Account of Various Observations made during the Voyage of H.M.S. 'Challenger' round the World, in the years 1872-76." By H. N. Moseley, M.A., F.R.S. 8vo. London: Macmillan. 1879.

As to the most important of these, it may, however, be a question whether they relate to the zoology of the sea or the land, the subjects of them being the sea-birds and seals. Upon the habits, and especially the nesting, of the noddies, frigate-birds, penguins, gulls, albatrosses, and other sea-birds which occur in such abundance on the almost inaccessible rocky islands scattered over both oceans, Mr. Moseley has much to say, and his descriptions of the "rookeries" inhabited by these birds are particularly interesting and valuable. But where all is so good, it seems rather invidious to select parts for special notice, and it will be almost sufficient to say in general terms that wherever the "Challenger" went, Mr. Moseley appears to have kept both his eyes and his mind open and active, and that he has been singularly successful in transferring his thoughts and observations to paper.

Upon a vast number of the subjects here treated of, although they may have been dealt with by previous writers, our author's remarks and reasonings possess an originality which gives them a special value of their own; whilst in some cases, as in the account of the curious genus *Peripatus*, and in the description of the hydrozoan corals, the Milleporidæ and Stylasteridæ, he gives us the results of his own original researches. The geological structure of the localities visited comes in for a due share of attention, and in connection with this department of science we find some valuable observations on the glaciation of such out-of-the-way spots as Heard Island and Kerguelen's Land. An entire chapter, and a most interesting one, is devoted to the author's observations among the antarctic ice, the phenomena presented by which in its various floating forms are described in considerable detail and illustrated by a good many figures.

The above are the principal natural history matters on which Mr. Moseley discourses at any length; but throughout his narrative we find scattered an infinity of useful observations upon the various interesting facts in zoology and botany which struck him during his long journey, both by land and sea, and his concluding chapter is devoted to a special review of the phenomena of animal and vegetable life at the surface of the ocean and in the deep sea as revealed by the investigations of the scientific staff of the "Challenger." This final chapter contains a great many philosophical reflections on the facts observed, and may be regarded as giving an excellent summary of the present state of our knowledge of pelagic and abyssal animals. At the same time it shows that in some respects there are still elements of uncertainty in the recorded observations. Thus according to the generally accepted views there is a surface fauna and a deep sea fauna, but we hear of nothing between them, although Mr. Moseley seems to think that the vast intervening space is not wholly uninhabited, and suggests a method of investigation which would probably give novel and interesting results. On the other hand, we have the curious connected facts of the occurrence of brightly coloured organisms, blind organisms, and others furnished with greatly developed organs of vision. Why should these peculiarities occur? If the assumed darkness of the bottom be the cause of the blindness of some species, why should others be so well provided with eyes? for we cannot believe that the latter organs would be developed, as Mr. Moseley suggests, for the purpose of making use of the light emitted by phosphorescent animals, of which,

moreover, we do not know that they are phosphorescent in their natural habitat at the bottom of the deep sea. Is it absolutely proved that these abysses are really in perpetual darkness, and that no microscopic plants live in them?

Besides recording his scientific observations, Mr. Moseley's narrative gives a pleasant and readable account of the terrestrial localities visited, their scenery, architectural and social peculiarities, and inhabitants. With regard to the last, indeed, our author has a good deal to say especially in relation to Japan (with which country and its occupants he seems peculiarly charmed), and several of the islands of the Pacific. When we consider that the course taken by the "Challenger," after leaving the southern ice, carried her by New Zealand, Tongatabu, the Fijis, the New Hebrides, the Moluccas, the Philippines, New Guinea, the Admiralty Islands, Japan, the Sandwich Islands, and Tahiti, and that at all these localities Mr. Moseley had, and made good use of, the opportunity of examining into the characters, habits, and manners of the natives, the reader will easily understand that scattered through his agreeable pages there is an immense amount of information which will be welcome to the student of anthropology. In fact, in every respect, this book is one of the most important contributions to our scientific literature that has appeared for a long time. The only thing that the reader will regret is that it is not rather more freely illustrated; the woodcuts, although generally good, are not numerous: and there are only three plates, two illustrating antarctic icebergs and pack ice, and the third a chart showing the track of the ship and the contours of the sea-bottom.

ANATOMY OF THE ELEPHANT.*

UNDER the title of "Studies in Comparative Anatomy," Professor Miall, of Leeds, has commenced the publication of a series of small volumes each of which is to contain the results of some personal investigation in comparative anatomy. The first of these treated of the structure of the skull of the crocodile, one of the most instructive subjects that the author could well have selected: in the second, which is now before us, he describes the anatomy of the Indian elephant, from a dissection of a young female specimen made by him with the co-operation of Mr. F. Greenwood. As this investigation relates especially to the muscles and other soft parts, it can hardly prove so generally attractive as the former treatise; but as it contains a great many new facts and corrections or completions of the statements of former authors, it will be of great value to that increasing body of comparative anatomists who do not consider that their study ought to be confined to the bones. The dissection of so large a beast as an elephant is a work of no small labour; it appears to have occupied the authors about three years, and they recommend to future dissectors of large animals the adoption of the mode of preservation employed by them, which is sufficiently described (p. 8).

* "Studies in Comparative Anatomy." No. II. "Anatomy of the Indian Elephant." By L. C. Miall and F. Greenwood. 8vo. London: Macmillan. 1878.

THE CHEMISTRY OF COMMON LIFE.*

PROFESSOR Johnston's "Chemistry of Common Life" has long been advantageously known for its simple and familiar method of introducing chemical facts and reasonings to the general reader. Treating, as this work does, of the air we breathe; we water we drink; the soil we cultivate; the plants we rear; the bread we eat; the beef we cook; the beverages we infuse: the sweets we extract; the liquors we ferment; the narcotics we indulge in; the odours we enjoy; the smells we dislike, &c., and concluding with a recapitulatory chapter upon the circulation of matter, it possesses great interest for all who are desirous of learning something of the chemical and physical relations existing between themselves and the world which they inhabit.

When, twenty-five years ago, "The Chemistry of Common Life" was first published, an acquaintance with the advancing science of the day was possessed by a very limited number only, even among the educated classes; and Professor Johnston's popular exposition of the fundamental principles regulating our daily life laid open to the public a new world of interest and speculation. In preparing the present edition for the press Professor Church has followed the arrangement and method adopted in the original work, and has made such additions and corrections only as the progress of science may have rendered necessary. He has, however, in the aggregate contributed much original matter, as well as an entirely new chapter on the colours we admire; besides which many of the new analyses, and particularly those of roots, are either wholly or entirely the results of his personal investigations.

The new chapter contains a notice of the red colouring matter of blood, now known as *hæmaglobin*, which contains iron, and differs from all other constituents of the body in various important particulars; among the most remarkable of which is its property of absorbing gases. On this latter peculiarity depends one of the chief uses of the blood as a carrier of oxygen throughout the system.

Another animal pigment, having a still more remarkable composition than that of hæmaglobin, and to which the name of *turacin* has been given, was, some years since, discovered by the editor in the pinion-feathers of ten or eleven different kinds of birds peculiar to Africa, and known as Touracous or Plantain-eaters. About fifteen feathers in each wing present patches which are almost entirely red, and a chemical examination of such feathers shows that they owe this colour to a pigment containing about eight per cent. of copper, so bound up with the other elements present as to be incapable of removal by any treatment short of the destruction of the colouring matter. The existence of an animal pigment so rich in copper is an exceedingly curious and interesting fact, but one of which the whole history is still far from being thoroughly understood.

The black feathers of some birds, black human hair, and, possibly, the skin of certain mammals likewise contain a dark pigment capable of resisting the action of tolerably strong sulphuric acid. Sorby obtained one

* "The Chemistry of Common Life," by the late James H. W. Johnston, F.R.S.S. L. & E., &c., a new edition brought down to the present time. By Arthur Herbert Church, M.A., Oxon. 8vo. Edinburgh and London: Blackwood & Sons. 1870.

grain of this substance from 100 grains of the feathers of the common rook, and found it to contain carbon 55·4, hydrogen 4·25, nitrogen 8·5, and oxygen 31·85 per cent. This chapter also furnishes much valuable information relative to the colouring matter of plants, such as leaf-green or *chlorophyll*, &c., as well as with regard to the more important of the coal-tar products employed for dyeing purposes.

Although the present edition appears in the form of a single volume, it contains a much larger amount of letter-press than former issues; and by judicious additions and careful revisions Professor Church has succeeded, not only in bringing the information down to date, but also in doing so without in any way changing the general system of the original work.

UNITED STATES SURVEYS.

In our last number we published an abstract of the Report of a Committee of the National Academy of Sciences on the Consolidation of the Surveys of the United States. We do not know what action, if any, has been taken upon this document, but most certainly the important Geological and Geographical Survey of the Territories over which Dr. Hayden so admirably presides shows no present signs of any diminution of its activity. Three stout octavo volumes which have reached us since our last issue seem to be anything rather than signs of decrepitude.

The tenth annual report* describes the completion of the survey of Colorado and the adjacent territories, and includes treatises on the geology, topography, archæology, and ethnology of that wonderful region, together with some notes by Prof. Lesquereux on cretaceous and tertiary fossil plants obtained by the survey in Colorado in 1877, and a catalogue by the same author of plants from the above formations in North America generally, and further, a report of Dr. Packard on insects affecting the cranberry and the pine. The catalogue of North American cretaceous and tertiary plants will be found especially useful.

The geological portion of the work consists of a series of reports from the geologists in charge of the different districts, completing the Commentary on the splendid atlas of Colorado noticed in our October number. As usual in each report the structural geology and superficial formation of the district are very fully described, and the latter offers a series of the most extraordinary phenomena that are to be seen anywhere on the face of the earth. All these parts are illustrated with a great number of plates of maps, sections, and views.

Of special reports under the geological head we may mention Dr. Endlich's description of the eruptive rocks of Colorado, a most important contribution to our petrographical knowledge; and the same author's mineralogical report, which includes an alphabetical catalogue and systematic arrangement of the

* "Tenth Annual Report of the United States Geological and Geographical Survey of the Territories, embracing Colorado and parts of adjacent Territories, being a Report of Progress of the Exploration for the year 1876." By F. V. Hayden, U.S. Geologist. 8vo. Washington: Government Printing Office, 1878.

minerals ascertained to exist in Colorado. The mining capabilities of the districts surveyed are mentioned in the geological reports.

The topographical section contains the report of Mr. A. D. Wilson, the chief topographer, on the primary triangulation of Colorado, giving many interesting particulars as to the methods adopted; special topographical reports on the White River and Yampa River divisions of the country; and Mr. Henry Gannett's report on the arable and pasture lands of Colorado, which includes a general description of the physical geography and climate of the region, besides the account of the capabilities of different parts of the country for agricultural and pastoral pursuits.

As illustrations of these two sections three of the large maps of the Colorado Atlas have been printed on thin paper, so as to be capable of folding into octavo size, and appended to the volume—namely, the general geological map of Colorado, the economic map, and the drainage map; and the addition of these adds greatly to the value of the book. In fact, so conscious are the people of Colorado of the importance of the labours of Dr. Hayden and his assistants that on January 14 last the General Assembly of that new state passed a vote of thanks to them for their co-operation in the completion of this great work, on the ground that "the publication of the reports, views, and maps of this survey form a collection invaluable alike for the advancement of science and the development of the mining and agricultural interests of the state." Those who are acquainted with the publications here referred to will agree that this expression of gratitude is well deserved.

The third section of the volume, which is devoted to the archæology and ethnology of the region, will be studied with much interest. It includes descriptions by Mr. W. M. Holmes and Mr. W. H. Jackson of a great number of those extraordinary ruins, towers, and cave-dwellings which have been lately discovered in such abundance in the far West, with details of pottery, picture-writings, stone implements, and other objects, manufactured by the former inhabitants of these valleys. These traces and relics of a race that has passed away are exceedingly interesting; and the reader is assisted in forming a clear idea of them by a most liberal allowance of illustrations, including maps, ground-plans, views, and figures of manufactured articles. Many pieces of the pottery are of very elegant form or beautifully ornamented; others are ruder, or exceedingly grotesque, such as the vessels in the form of birds which figure upon three or four of Mr. Jackson's plates.

In Chaco Cañon, North-western New Mexico, a human skull was discovered "at a depth of 14 feet beneath the surface, lying upon a stratum of broken pottery." The soil overlying the skull is described as alluvial drift. Dr. W. J. Hoffman describes and figures this cranium, which he regards as having belonged to a "cliff-dweller"; it presents a very great flattening of the hinder part of the skull. Dr. Hoffman also communicates some ethnographic observations on Indians inhabiting Nevada, California, and Arigona, giving some interesting particulars as to the manners and customs of the various tribes.

Still referring to Colorado, we have to notice the commencement of Dr. Elliott Coues' "Birds of the Colorado Valley,"* forming the eleventh volume

* "Miscellaneous Publications, No. 11. Birds of the Colorado Valley, a repository of scientific and popular information concerning North American

of the miscellaneous publications of Dr. Hayden's Survey.—This first part, which contains the descriptions of the Passerine birds from the thrushes to the shrikes (including warblers, tits, creepers and wrens, larks, wagtails, tanagers, swallows, waxwings and greenlets) occupies 565 pages, so that it will easily be understood that the subject is treated in some detail; in fact, the feelings suggested to the British zoologist by the contemplation of such a book have a slight tinge of envy in them, seeing that he can never hope to get an opportunity of displaying to such advantage the results of his labours. Dr. Coues gives a detailed synonymy of each species, followed by a Latin diagnosis and a description in English, and then indicates the general natural history of the bird, and indulges in any critical remarks that may occur to him. The latter are often of considerable importance both with regard to genera and species. He also adds in many cases notices of other American species nearly allied to those inhabiting the district to which his work specially relates, and sometimes even tabulates all the species of a genus, a plan the adoption of which is very useful in works on local natural history. The illustrations (seventy in number) consist of woodcuts generally of heads and other important parts, and although not remarkable as works of art, are generally sufficiently characteristic.

Curiously enough, we find Dr. Coues reviving the old question as to the hibernation of swallows which we had thought had been set at rest long ago. He does not indeed affirm his positive belief in their passing the winter, as alleged, buried in mud at the bottom of ponds and rivers, but he declares that the occurrence of this phenomenon rests on as good evidence as many other things which are accepted as facts in natural history, and that his mind, at any rate, is open to conviction. He says, "I see no reason why a swallow should not stay awhile in the mud in a state of suspended animation, or greatly lowered degree of vital activity. The thing is physically and physiologically feasible; it is in strict analogy with observed phenomena in the cases of many other animals; and it is not more marvellous than catalepsy, trance, and several other conditions of life, the rationale of which is still obscure." The point from which the *à priori* argument against the hibernation of swallows in mud starts is, however, precisely the conviction that such a phenomenon is *not* "physiologically feasible"; and even Dr. Coues himself adverts specially to the difficulty of explaining "the suddenness of the alleged transition from a high state of animation to a degree of lethargy, and the abruptness with which the activity of the vital functions is said to be arrested." His supposed analogy drawn from the swifts is really, when we come to consider it, no analogy at all; and we do not actually know of any bird that has been proved to hibernate, hibernation being in reality (*à priori* at any rate) incompatible with the physiological constitution of birds. It must be confessed, however, that in reviving this question, Dr. Coues has done all in his power to furnish the means for its solution, in the shape of an elaborate bibliography of the subject extending over nearly a dozen pages. Ornithological bibliography must, indeed, occupy a considerable portion of Dr. Coues' attention, for besides the piece above alluded to, we find close by

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Ornithology." By Elliott Coues. Part I. 8vo. Washington: Government Printing Office, 1878.

a special bibliography of the waxwings (genus *Ampelis*, Linn.), and these are stated to be only portions of a great Bibliography of Ornithology not yet completed, but of which one section, namely that showing "the North American section of the 'Faunal Publications' series, including titles and digests of works and papers relating solely to birds of North America indiscriminately, collectively, or in general," is published in advance as an appendix to the present volume. When we say that this portion relating solely to works and memoirs on the general avifauna of North America, or containing notices of birds not confined to any particular group, occupies nearly 180 pages, some idea may be formed of the labour which the compilation of the whole must have entailed upon the author. The titles of the works here are arranged in order of date, but to facilitate reference the list is provided with two alphabetical indexes, one containing the names of authors, and the other the localities referred to. This bibliography will prove of the greatest value to all ornithologists.

Few are the insects that have been honoured by having a special treatise all to themselves. The goat-moth caterpillar—"*La chenille qui ronge le bois de saule*"—was anatomically immortalised by Lyonet; the hive-bee and the silkworm have had many panegyrists; the cochineal, a much smaller species, has also had its independent book; and Southall devoted his "Treatise of Buggs" to a subject which most people will regard as rather unsavoury. The Colorado potato-beetle, also popularly described as a bug, had his little treatises all to himself; but with this, so far as our recollection serves, the list of species of insects which have arrived at the dignity of having their history narrated in separate publications, is pretty nearly exhausted.

The Rocky Mountain locust (*Caloptenus spretus*) has now to be added to this honourable list, in consequence of the publication of a volume of nearly 800 pages devoted exclusively to the history of his life and misdeeds, and to the best mode of punishing him for the latter, and preventing his ravages in the future.*

This elaborate report, which is also brought out under the auspices of the Geological and Geographical Survey of the Territories, is the joint production of MM. C. V. Riley, A. S. Packard, Jun., and Cyrus Thomas, and it is not too much to say that it reflects the highest credit upon them. Of the importance of the subject to the United States some conception may be formed from the fact that the Commissioners estimate the loss from the ravages of this locust to the states between the Mississippi and the Rocky Mountains, during the five years 1873–77, at 200,000,000 dollars, and they point out that the injury thus inflicted was the more severely felt as the losses fell most heavily upon a frontier population without wealth.

The permanent habitation of this formidable locust, which is, however, individually but a small insect, about the size of an ordinary English grasshopper, is a great stretch of country lying principally east of the Rocky Mountains, extending northwards into British territory, and including within the United States the territories of Nebraska and Wyoming, and portions of Colorado, Dakotah, and Nebraska. Here the species is always to be found

* "First Annual Report of the United States Entomological Commission for the year 1877, relating to the Rocky Mountain Locust." 8vo. Washington: Government Printing Office, 1878.

in more or less abundance, and hence it makes its injurious raids upon the more highly cultivated districts lying around it. In a considerable stretch of country lying east of these permanent abodes of the locust, the insect is described as subpermanent, that is to say, its invasions are there very frequent; and further, it is in the habit of breeding there for several consecutive years, after which it again disappears for a time. Over a much larger extent of country, reaching southwards to the coast in Texas, and stretching westwards through Colorado over a considerable space west of the Mountains, the locust is said to be temporary, visiting those regions only periodically, and generally disappearing within the year. The migrations of these insects take place in two directions; that is to say, while the invaders make their way in all directions from the permanent breeding grounds, the young locusts hatched out in the temporary regions migrate in the opposite direction, or back towards the permanent abode of the species; and the Commissioners state that it is well established that there may be, at the same time, two contrary currents over considerable areas. At the same time, it is remarked that many of the returning insects are so infested with parasites, and otherwise diseased, that they perish during their homeward journey.

The habits and natural history of the species are fully described by the authors, who also indicate the characters by which it may be distinguished, from nearly allied but distinct species also inhabiting the North American continent. They further describe minutely the anatomy and embryology of the locust, and explain its transformations, and, in fact, furnish the reader with all the information necessary to enable him to form an intelligent conception of the nature of this scourge of the Western farmer. A more encouraging chapter is that which treats of the insect-enemies of the locust, which fortunately appear to be pretty numerous and active in their operations—to the entomologist this will be one of the most interesting portions of the work. A great many birds also aid materially in checking the increase of the pest. Three chapters are devoted to the consideration of the available modes of destroying the locusts by artificial means, some of which are ingenious enough, but need not be referred to here. A chapter on the effects produced on the fauna and flora of different localities in consequence of devastation by locusts is very interesting and instructive. The authors notice the occurrence of locusts in other localities, especially in countries bordering upon mountain ranges; but as a set-off against the mischief done by the insects, they indicate that they are available "as food for various animals, including man, as fish-bait, or as manure," and further that "the chemical analysis given of the dead locusts is quite interesting. The insects furnish a new oil, which we have christened Caloptine, and a very large percentage of formic acid." Of their properties as food Mr. Riley speaks from experience in very favourable terms. A great body of evidence bearing on the subject of the report is given in a series of appendices. The volume is illustrated with several maps and numerous wood engravings, and with five very nicely executed plates, three of them showing the distinctive characters of the three North American *Calopteni* referred to in the text, the fourth representing the hypermetamorphoses of the coleopterous genera *Epicauta* and *Hornia*, distinguished enemies of the locust, and the fifth illustrating certain points in the histology of the latter.

A MYCOLOGICAL REVIEW.*

IT is a question that must of necessity force itself upon the mind of nearly every naturalist, whether we are not getting overdone with periodical literature. Every little Philosophical Society that exists all over Europe publishes its contribution to the literature of science, and although most of the articles contained in these almost inaccessible serials are commonplace enough, still, from time to time, they contain the results of sound original observations with which it is of importance that all students of the subject treated of should be acquainted. In other cases we have local Natural History journals brought out, either by individuals who find a pleasure in editorial work (!), or by a combination of local societies, and these are in precisely the same position as the former. We cannot help thinking that this indefinite multiplication of serial publications, in any one of which a valuable paper may be buried without the least chance of being generally known to those interested in it, is a great misfortune, as it involves a totally unnecessary widening of the literary field which the naturalist must explore, and which is wide enough in all conscience without these additions.

A similar objection may perhaps be raised against the production of journals, transactions, and other serial works intended specially for the reception of papers upon some particular class or order of plants or animals; but, although these have, to a certain extent, the same effect of multiplying the receptacles which the student must search through in order to acquaint himself with what has been done, they, nevertheless, in their very title tell him what he may, or rather, what he need not, expect to find; and for those who devote themselves more particularly to one department of Natural History, it must be confessed that they present a great advantage. Further, by notices of new publications, and abstracts of papers published in other more general journals, they furnish the specialist with a reflection of what is going on elsewhere in his favourite pursuit, and enable him, if he chooses, to procure all the best literature relating to it.

For these reasons, we welcome the appearance of the first number of a quarterly "Revue Mycologique," edited at Toulouse by M. C. Roumeguère, and can only hope that its existence may not be typified by that of the plants whose history and peculiarities it is intended to record. At the same time we cannot help feeling that the editor's undertaking is at least as "courageous" as those of the gentlemen who have started the "Revue Bryologique" and "Revue d'Algologie," to which he refers in his opening address to his readers.

This first number contains several articles by the editor—one in opposition to the notion that Lichens are Fungi parasitic upon Algæ, another on an extraordinary development of *Bovista gigantea* near Toulouse, a third on the origin of the genus *Microsphæria*, a fourth on the preservation of Fungi, and a fifth on *Telephora palmata*, forma *paradoxa*. We also find a decade of new Exotic Fungi described by M. F. von Thümen; an article on the

* "Revue Mycologique, Recueil trimestriel illustré, consacré à l'étude des Champignons." Dirigée par M. C. Roumeguère. 1re Année, No. 1. 8vo. Toulouse, 37 Rue Riguet, et Paris, J. B. Baillière. January 1879.

Myxogastres by Dr. L. Quelet; and one by the Count de Castillon on the Artificial Culture of Mushrooms by the Japanese. A paper by M. Paul Brunaud on the popular names of Fungi in the neighbourhood of Saintes contains notes on the characters of two or three species. A plate which accompanies the number does not appear to belong to any of the papers contained in it. The number furnishes bibliographical notices of a great number of books and papers published in 1878, and concludes with a few pages of short notes on mycological subjects. If this review can be continued in the same style, it will doubtless prove exceedingly useful to students of Fungi; but we should fear that its circulation will be very limited, and, probably in anticipation of this, its price seems to be rather high.

HEALTH PRIMERS.*

THE six little volumes which have appeared of this very useful series are remarkable for their sound common sense treatment of important subjects, and for their cheapness. In this last respect these primers resemble many others which have appeared from time to time, and which have been the work of the most distinguished physicists, anatomists, and botanists of the day; but they differ from them by being within the comprehension of those individuals for whom primers are written. A primer in the olden time was a book which related to the fundamental principles of a branch of knowledge, and it was written in plain and almost monosyllabic English; but many modern ones are comprehensive "crams," and *prime* up the student with the incomprehensible. The one was "milk for babes," the others are "strong drink" for the old; the old books were for the beginner, and the modern are only really appreciated by those men who know all about the subject. Certainly these little books can be understood by everybody; they are didactic as well as suggestive; and in reading them one is struck with the evident improvement in the method of thought of the medical profession, for they are edited and written by distinguished members of the faculty. They are the outcome of the third phase of medical thought during this century. Early in it, the doctors were heroic; people were bled, blistered, and draughted, and were taught that every disease had, or ought to have, its special curative agent. Then, as the medical mind became logical, the expectant treatment prevailed; and now primers are written on "preventive" medicine or sanitary science. Formerly every epidemic was attributed to the anger and personal attack of the Ruler of all things, and was considered to be a warning against national and other sins. Now such disorders are believed and are proved to be the result of man's stupidity, dirt, bestiality, and bad government. The little volume on "premature death"—that is to say, death before the expiration of the natural term—deals with the community rather than with the individual, and tells the true story of the cause and

* "Premature Death: its Promotion and Prevention." "Alcohol: its Use and Abuse." "Personal Appearance in Health and Disease." "The House and its Surroundings." "Exercise and Training." "Baths and Bathing." Royal 16mo. London: Hardwicke & Bogue.

perpetuation of those preventible diseases which are a scandal to the country. It explains the influence of artificial conditions and methods of life on the young and old, and very ably notes the influence and reactions of destitution on disease. It is pleasant to read the grateful recognition of the services of "the great master in sanitary science and craft in this country, John Simon," a man to whom England owes a mighty debt of gratitude, a man who has saved and not slain his thousands, and who in our present, militant, money-grubbing, semi-barbarism is plain "John Simon." The primer on "Alcohol: its Use and Abuse," will not please either the total abstainer or the wine-selling grocer tribe. It is written by a thinker, and the following sentences prove it:—"Moral character is very largely influenced by habit, by the acquired control of the highest cerebral centres over the lower; and hence the continual paralysis of that control, and the constant abolition of all power of self-restraint, must, of course, aid largely in moral deterioration." "The habitual drunkard is morally defective from the outset, and his habits give full play to the action of all the lower tendencies of his nature. Drunkenness is more a vice than a disease." The author then affirms, with regard to moderate or excessive drinking, "that whatever quantity causes any temporary loss of moral control does, if repeated, lead to moral deterioration, but that short of this no such result is produced." At the close of this book there is a very solemn warning against the use of stimulants in painful diseases; it is for the especial benefit of those who run a chance of being made slaves to the bottle by illogical *medici*. The house we live in—too often a den of malignant bacteria, bad gases, and smells—is treated of in one of the primers in a very downright manner. If builders have consciences, and would only read this book, what a blessing it would be! The remaining volumes are on the special subjects of exercise and baths, and, like the others, are full of suggestions and of very good advice. We can earnestly recommend these able volumes to the public.

THE LIBRARY OF THE MUSEUM OF PRACTICAL GEOLOGY.*

WE may call the attention of those of our readers who are interested in geology to the very useful Catalogue of the contents of the library of the Museum of Practical Geology, which has just been published. It has been prepared with great care by Mr. Henry White, the compiler of the Royal Society's catalogue of scientific memoirs, and Mr. T. W. Newton, the assistant-librarian at Jermyn Street, and is not only an excellent example of a practical library-catalogue, but, from the nature of its contents, giving as it does a list of accumulations of geological and mineralogical works especially during a period of some twenty-seven years, it will prove exceedingly useful, even apart from the library to which it particularly relates, as an index to the literature of geology and the allied sciences. Very wisely the compilers have abstained from all fancy methods of arrangement, and have

* "A Catalogue of the Library of the Museum of Practical Geology and Geological Survey." Compiled by Henry White and Thomas W. Newton. 8vo. London: Printed for Her Majesty's Stationery Office. 1878.

kept absolutely to an alphabetical order, certainly the most convenient for reference; at the same time certain articles have been collected under special heads, but always, where necessary, with cross-references. By the use of black letter for the names of authors, &c., the book is rendered particularly easy to consult.

GEOLOGICAL SURVEY OF ESSEX AND HERTS.*

WE have received from the authors a copy of the memoir on Sheet 47 of the Geological Map of England and Wales, published under the superintendence of Mr. Whitaker, in which that gentleman and his colleagues carry farther to the northward the geological survey of the London basin, so well treated by him in a former memoir. The present work relates to the north-west of Essex and north-east of Hertfordshire and takes in small portions of Cambridgeshire and Suffolk. It thus carries the survey of the London basin up to its northern boundary, where Cretaceous beds occur; and the greater part of the remainder of the area is formed by the London Clay, the exposure of the Thanet and Reading beds being very small. The surface is covered to a great extent with drift deposits of various kinds; but traces of the Red Crag are met with here and there in the north-eastern part of the area, especially in the neighbourhood of Sudbury. The memoir displays the usual accuracy and completeness characteristic of all work with which Mr. Whitaker has anything to do; but, good as it is, we do not understand why its cost should be quite so high—three-and-sixpence for a pamphlet of ninety-two pages, with nineteen woodcuts, will seem to unsophisticated people a little too much

WILLIAM HARVEY.†

HOW easy it is to depreciate; how hard it was to demonstrate the circulation of the blood; how incomprehensible it is to the multitude that scientific men should be so long in finding out such very evident things, are expressions which always must come forth on reading any life of William Harvey, and the criticisms of his contemporaries and successors. Poets, play-writers, and imaginative but not practical anatomists, had stated that the blood moved here and there, and that there was a circulation of it; but Harvey demonstrated the true circulation of the blood, and did not deal with fantastic imagery or a cyclical movment which, like that of Cæsalpinus, was not the true one. Why was the great fact that the arterial blood is propelled forth by the heart, and that it enters the veins by minute capillaries and returns, not found out before so late in the world's history? Its elaboration was opposed by the prejudices of mankind, by the pernicious

* "Memoirs of the Geological Survey, England and Wales. The Geology of the North-West Part of Essex and the North-East Part of Herts (explanation of Sheet 47 of the Map)." By W. Whitaker, W. H. Penning, W. H. Dalton, and F. J. Barnett. 8vo. London: Printed for Her Majesty's Stationery Office. 1878.

† "William Harvey. A History of the Discovery of the Circulation of the Blood." By R. Willis, M.D. London: C. Kegan Paul & Co. 1878.

domination of priestcraft, and by the want of the inductive and experimental method of reasoning. Like all great discoveries, it was led up to, and it was facilitated by the revolution in morals, religion, and method of thought which was proceeding. Dr. Willis places the ideas of the ancients and of those of the modern predecessors of Harvey most fairly before the world, and gives the proof that our great countryman not only taught the truth, but demonstrated it. Everyone before him had taught untruth, or only part of truth, and no one had demonstrated. Now, at the present day, scientific men do not acknowledge the imaginator as the discoverer, but the experimentalist, who proves and places a fact as a useful truth before the world. Everybody knows that Joule of Manchester demonstrated by experiment the mechanical equivalent of heat; but to Mayer we only owe thoughts on its possibility—the one is the discoverer, and to the other the world owes nothing. The Greeks progressed wonderfully in anatomy, and their great knowledge of the heart and vessels may be said to have culminated in Galenus of Pergamus, born 131 A.D., whose works ruled medical and anatomical science for thirteen centuries. Amongst the first of the modern imaginators, but who believed one kind of blood to be distributed by the veins for growth and maintenance, and another by the arteries, charged with heat and spirit for vital endowment, was Rabelais, and he certainly knew much anatomy. Sylvius followed and injected the arteries, but missed the significance of the obstructing valves in the veins. Winter of Andernach, the master of Vesalius and Servetus, demonstrated and described the valves of the heart, and noted the influence of the air on the blood in the lungs. Vesalius was a pure anatomist, but he considered that the motion of the blood was of a to-and-fro kind, and did not realise the importance or physiology of the venous valves. Persecuted by the Inquisition, he perished miserably in returning from a forced pilgrimage to Jerusalem. Servetus followed, and, strangely for the age, was a reformer in religion and a physiologist. He stated that the blood moved from the right to the left side of the heart through the lungs, in his work on the Restoration of Christianity, for which book he was burned by Calvin, the Protestant. He was aware of the peculiarities of the fœtal lung, and of its having no independent existence. Columbus (Realdus) described the vena portæ particularly, but denied muscularity to the heart. Eustachius discovered the thoracic duct in the horse, and its relation to the great venous trunk of the neck; and Fallopius intensified the belief that the veins were the distributors of blood, instead of the arteries. Sarpi, before his age in learning, was nearly assassinated by the orders of Paul V., but he did not add as much as did Arantius, who showed how the perfect closure of the heart's valves was produced. Then came Ruini and Cæsalpinus, neither of whom, however, were discoverers. Fabricius began the truth by demonstrating the presence and functions of the valves in the veins; and, finally, Rudius, knowing nothing of the function of the heart, and who believed that the pulmonary artery drew air into the left ventricle, (!) paved the way for Harvey, of Folkestone. His "Exercise on the Motions of the Heart and Blood" checked his professional prosperity, and all the "physitians" were against him; but in after years, and after the appearance of his "Generation of Animals," his brother physicians put up an inscription which gave him the credit for his great discovery. Dr. Willis describes the splendid work of this great man in a most readable and scholarly manner.

A MINISTRY OF HEALTH, AND OTHER ADDRESSES.*

THIS highly interesting volume contains upwards of nine addresses, written in the author's well-known style, and full of great and good thoughts. The first deals with the proposal to have a Minister of Health, and Dr. Richardson would make the appointment a permanent one, and it should be held by no party man. The next refers to William Harvey. A capital discourse on the inter-relationship of clerical and medical functions follows. In the chapter on Learning and Health there is an onslaught on needless competitions and the evils of the examination system. In the "World of Physic," pp. 209, 210, there is an awful but painfully true description of the oppositions to the aspirations and duties of the physician on the part of society; and the book closes with a very curious and suggestive chapter on the comparative merits of alcoholic and etherial drink. The work is like all those of the author—that of a man of genius, of great power, of experience, and noble independence of thought.

RAINFALL AND SUNSPOTS.†

UNDER the title of "Rainfall of the World," Mr. Archibald sends us a pamphlet comprising an essay, an introduction, and an appendix. In the introduction the author deals with solar energy, and assumes that this energy, being constant, is displayed at one time in the disturbance of the solar gases, as shown by the prominences and spots on the surface of the sun; at another in the maintenance of a high temperature; and concludes that the physical state in which the sun may be at any given time affects this earth by direct magnetic action, and by variations in the amount of heat radiated from the surface of the sun. The period of maximum intensity of one set of conditions is that of minimum intensity in the other. Years of minimum sunspot consequently show fewer magnetic storms, but higher temperatures, than years of maximum sunspots; and the author considers that the researches of numerous meteorologists, but more particularly of Köpper and Hahn, would appear to render the fact indisputable that periods of sunspot minima are those of maximum temperature.

As all meteorological phenomena are directly attributable to variations in temperature, through the winds which these variations occasion, the author in the essay divides the surface of the earth into five different zones, according to the winds, which are the vapour-bearing currents to each district. By dealing with each zone separately, according to its special local and geographical conditions, it becomes possible to explain away many apparent incongruities in the rainfall of different localities. Selecting from Zone II. the rainfall of Madras, a direct variation with the solar spot frequency is shown, and it is hardly possible to avoid connecting the regular variation of drought and plenty with the presence or absence of large numbers of sunspots

* By Dr. Richardson, F.R.S. London: Chatto & Windus. 1879.
† "The Rainfall of the World." By E. D. Archibald. 8vo. Calcutta: Thacker, Spink & Co. 1878.

In Zone V., which embraces France, North Italy, Germany, and Russia, in those places where most of the rain occurs in the summer, the rainfall apparently varies directly with the sunspots; while in the case of the wet season, being the winter, the rainfall varies inversely, the very same changes in the physical state of the sun acting in totally opposite directions under the different conditions. It is evident, not only from a fact quoted by Mr. Blanford, namely, that the rainfall at Madras in 1860—a year of maximum sunspots—was lower than that for any other year between 1832 and 1867, but also from the author's own work, that it is impossible to look for any broad distinctive secular changes in the rainfall of the world, and that it will only be by minute research, and the elimination of local peculiarities, that the cyclical variations, if existing, will be discovered. In his appendix the author discusses the question of the relation between sunspots and cyclones.

SEWAGE POISONING.*

So many evils are due to the influence of sewage-gas escaping into our houses that we cannot but welcome every sensible suggestion that aims at keeping out so dangerous an inmate—a visitor, indeed, whose mere presence in a house is generally so disagreeable to the senses that it is a wonder people treat it with so much indifference. In a lecture delivered before a London Medical Society, and just published as a pamphlet, Dr. E. T. Blake discourses of the various diseases which may be traced, directly or indirectly, to the influence of sewer-gas, of which, as might be expected, he gives a sufficiently formidable list, pointing out especially that, besides those more acute affections which every now and then produce general alarm by their local prevalence and often fatal termination, there are a host of apparently less serious complaints which nevertheless are productive at least of much trouble and uneasiness, and by their long continuance cause serious injury to the health. By a description of the usual arrangements adopted for the conveyance of the sewage of our London houses to the main sewer, Dr. Blake shows how ingeniously these are contrived to facilitate the ingress of the deleterious gases, and, indeed, in many cases for enabling them to reach and accumulate in just those parts of the house from which they ought most carefully to be excluded; but having drawn this unpleasant picture, he does not abandon his readers to despair, but indicates pretty fully the course to be adopted in order to secure the exclusion of the unwelcome and mischievous intruder. Dr. Blake's pamphlet is illustrated with a series of woodcuts contrasting things as they are and as he thinks they should be, and there is no doubt that a great improvement in the sanitary state of our houses would be effected by the adoption of the rules which he has laid down.

* "Is Diphtheria Preventable?—Sewage Poisoning: its Causes and Cure." By Edward T. Blake, M.D. 8vo. London: Hardwicke & Bogue. 1879.

DOMESTIC POISONS.*

IT is a pretty well-known fact that certain bright green wall-papers contain a considerable quantity of arsenic, and that this deleterious substance is not so firmly fixed to the paper as to be incapable of detaching itself and floating about in the air as a poisonous dust. Of the ill effects produced by this dust there is abundant medical evidence; and from some observations it would appear that in certain cases, even when the arsenical compound is unable to break away in the solid form, an evolution of arseniuretted gas may take place and produce an equal amount of mischief. Mr. Henry Carr has collected a considerable body of evidence bearing upon this subject and other collateral matters connected with this insidious mode of introducing virulent poisons into our houses, and has published the results of his investigations in a small book, which certainly opens up a sufficiently alarming prospect. He finds that, contrary to the general opinion, the presence of arsenic is by no means confined to papers and other articles of domestic use of a bright green colour, but that many dull green articles are equally dangerous, and in fact that, thanks to the numerous modern applications of chemistry to the arts, a great number of colouring materials in common use contain arsenic, even when there is nothing green about them. The aniline dyes, for example, are not unfrequently contaminated by a residue of the arsenic used in their preparation. Mr. Carr cites a long list of things which may be rendered dangerous by the employment of poisonous dyes—articles of clothing, curtains, &c.—and cites a sufficient number of authorities to show that there is a grave reality in the charge he brings against many modern manufactures of domestic use. His main object is to call the attention of the public to the matter, with the view of obtaining legislative interference in the interests of public health.

ÆSTHETICS.†

ÆSTHETICS, like Social Science, is, it appears to us, so much in its infancy, notwithstanding the many writers on the subject, that it in fact has scarcely yet earned for itself the title of a science at all, for hardly any two writers appear to agree even as to its definition; and a science which is yet so crude that its very exponents hardly know what are the bases of the subject on which they write scarcely seems deserving of the name at all. M. Véron, however, gives his definition thus: "Æsthetics is the science whose object is the study and elucidation of the manifestations of artistic genius," which is certainly brief enough—and, as the author very justly remarks, avoids those "inconveniences and obscurities" into which others, who have perhaps endeavoured to give a juster, or at least a more detailed, definition have been led. As a treatise on Art, however, the book is ex-

* "Our Domestic Poisons; or, the Poisonous Effects of Certain Dyes and Colours used in Domestic Fabrics." By Henry Carr. Sm. 8vo. London: W. Ridgway. 1879.

† "Æsthetics." By Eugène Véron. Translated by W. H. Armstrong, B.A. "Library of Contemporary Science." London: Chapman & Hall. 1879.

tremely interesting, and is one which may be taken up at any time for light and pleasant reading. It seems, however, unfortunate that in a book intended for the English reader all, or almost all, the illustrations are taken from French authors and artists, no mention being made throughout the book, unless we are much mistaken, even of such men as Hogarth, Reynolds, Gainsborough, Turner, and Ruskin. In the translation there is, it seems to us, one serious error: in a work translated from the French one does not expect to find such words or phrases as *bizarreries*, *en rapport*, *qui vive*, and many more, which are scattered through the book, while we cannot see any reason why "*Dieu me pardonne*" should be left in French in a quotation which, with that exception, is translated into English.

SCIENTIFIC SUMMARY.

ASTRONOMY.

Meteoric Dust.—Mr. Ranyard has contributed to the "Proceedings" of the Royal Astronomical Society a very interesting paper on the presence of meteoric dust in the atmosphere. Professor Andrews announced in 1852 that he had discovered particles of native iron in the basalt of the Giant's Causeway, and suggested that they may have been derived from meteors which fell when the basalt was in a plastic condition. In 1867, Mr. Phipson, in a book on meteors, said: "I have found that when a glass covered with pure glycerine is exposed to a strong wind, late in November, it receives a certain number of *black angular particles,* some three or four of which may be thus collected in the space of a couple of hours." These can be dissolved in strong hydrochloric acid, and produce yellow chloride of *iron* upon the glass plate." He adds: "Although I have made this experiment at various periods of the year, it is only in the winter months that the black particles giving, with hydrochloric acid, chloride of iron, have been met with." Towards the end of 1871, Nordenskjöld collected some apparently pure snow which fell in the neighbourhood of Stockholm during a heavy snowstorm, and on melting a cubic mètre of the snow he found that it left a black residue, from which he was able to extract with a magnet particles which, when rubbed in an agate mortar, exhibited metallic characters, and on being treated with acid proved to be iron. Nordenskjöld also found particles of magnetic iron in snow which he collected from off the ice of Rantajerwi, a spot separated by a dense forest from the nearest houses at Evoia, in Finland. The Arctic Expedition of 1872 led to results still more striking, black granules containing iron, phosphorus, cobalt, and probably nickel, being found in snow collected in spots very remote from human habitations. M. Tissandier has described the particles of solid matter found in deposits of dust on the towers of Notre Dame as resembling those which he was able to detach by friction from the surface of meteorites, and concludes "that they are the solidified metallic rain detached from meteoric masses during their passage through the atmosphere." Dr. Walter Flight published, in 1875, an important paper describing a kind of grey dust which he calls *cryoconite,* met with in holes in Polar ice, and forming a layer of grey powder at the bottom of the water filling the holes. He says: "The origin of cryoconite is highly enigmatical. That it is not a product of the weathering of the gneiss of the coast is shown by its inferior hardness, indicating the absence of quartz,

the large proportion of soda, and the fact of mica not being present. That it is not dust derived from the basalt area of Greenland is indicated by the subordinate position iron-oxide occupies among the constituents, as well as by the large proportion of silicic acid. We have, then, to fall back on the assumption that it is either of volcanic or cosmical origin! . . . Whencesoever it comes, it contains one constituent of cosmical origin. Dr. Nordenskjöld, extracted, by means of the magnet, from a large quantity of material sufficient particles to determine their metallic nature and composition. These grains separate copper from a solution of the sulphate, and exhibit conclusive evidence of the existence of cobalt, copper," and nickel (less certainly).

From evidence of this kind Mr. Ranyard infers that meteoric matter is continually falling in quantities which, in the lapse of ages, must accumulate so as materially to contribute to the matter of the earth's crust. He speaks of this theory, by the way, as one which has been advocated, for some time past, by Mr. Proctor. But this is not strictly correct. Mr. Proctor has advocated the theory that in remote past ages the earth has thus received material increments of mass, but not that meteors are now falling in such sort as to increase the earth's mass, even during many hundreds of thousands of years, in any appreciable degree. The total number of meteoric bodies falling annually on the earth's mass, from the largest aerolites down to the smallest shooting-star which an ordinary telescope would show (if the body chanced to pass across its field of view), has been estimated by Professor Newton, of Yale College, at 400,000,000. This only allows an average of two meteors per annum for each square mile of the earth's surface; or roughly about one meteor per square yard, in 1,500,000 years. As the average weight of meteors is probably to be measured rather by grains than by ounces, we cannot consider that the addition of one meteor per square yard would involve a very noteworthy increase of the earth's mass; and 1,500,000 years must be regarded as fairly equivalent to the time indicated by the rather vague expression, "the lapse of ages." In past times, however, when as yet the great bulk of the meteoric matter was still travelling freely around the sun, the rate of ingathering must have been far more rapid.

The Lunar Crater Hyginus.—Lord Lindsay and Dr. Copeland have made some interesting and instructive observations on the varying appearance of the region near Hyginus, confirming, as they point out, the well-known fact that this region "is full of complicated shallow irregularities and strongly-marked differences of tone, which tend together to produce great apparent changes of surface configuration, with change of illumination; and, further, to show that there exist striking features in the immediate neighbourhood which have hitherto escaped clear detection, but of which some traces may be found in the comparatively old map of Lohrmann." Their statements would hardly be intelligible, even to lunar students, without the drawings which accompany their paper. Let it suffice to observe, that they fully make out their case; and though their observations have no direct bearing on Dr. Klein's supposed recognition of a new crater in this region, yet indirectly they tend to increase the doubt with which the more cautious astronomers had received the announcement of the reported change. The facts collected also show, as Lord Lindsay and Dr. Copeland say, "with

what extreme caution all presumed evidence of change on the moon's surface ought to be received, and how necessary it is to accumulate observations made under various and particularly under *low* illumination."

The "Bedford Catalogue."—Admiral Smyth's Cycle of Celestial Objects, commonly called the "Bedford Catalogue," is used by so many telescopists, and has been so long regarded as an authority, that many will hear with pain as well as surprise of the announcement by Mr. Herbert Sadler, after careful examination of many statements in the work (vol. ii.), that it is utterly untrustworthy. He adopts and emphasizes the remark of that most careful and skilful observer of double stars, Mr. Burnham, that "no publication of original observations, in this or any other language, can be named which contains so many serious errors." "The measures of the Struves, Dembowski, Dawes, Secchi, and half a dozen others whose names might be mentioned," adds Burnham, "do not contain altogether more than a small fraction of the mistakes in the Cycle which have led to so much discussion and confusion. . . . Ordinarily there is no difficulty in detecting the mistake at once. This is not the case with the Cycle. There is no theory which will account for the many serious discrepancies. The measures generally agree substantially with those which are given from prior observers, but the strangest part is that the agreement is kept up just the same where the earlier measures are all wrong." This statement, it will be noticed, involves a somewhat serious charge, which those who are interested in supporting the reputation of the late Admiral Smyth would do well not to overlook. We shall hope to see the cases adduced by Mr. Herbert Sadler explained on some other hypothesis than that Admiral Smyth "fudged" (to use a schoolboy phrase) some of his observations. Not content with shaking our faith in this older catalogue, Mr. Sadler makes a most damaging reference to a catalogue published quite recently, at great expense, by the Royal Astronomical Society. "As far as I am aware," he says, "there is one catalogue only, and that not an original one, which surpasses the 'Bedford Catalogue' in inaccuracy, and that catalogue is the 'Reference Catalogue of Multiple and Double Stars,' forming Vol. xl. of the Memoirs." It is to be hoped that Professor Pritchard, who with the late Dr. Main shared the responsibility for the last-named most remarkable production, will endeavour to show that it is either not so bad as it is commonly reported to be, or that there is some valid excuse for its being, as many allege, altogether valueless.

Phenomena Observed at the Occultation of a Star by the Moon.—Mr. Christie describes a curious pheenomenon presented at the occultation of the fourth magnitude star 17 Tauri by the moon, on November 10, 1878. He observed with nearly the full aperture of the Great Equatorial (nearly 13 inches). As the star approached the moon's limb he observed it steadily, fearing to lose it in the overpowering brilliancy of the moon's light. He expected it to disappear at a slight notch in the moon's bright limb; but instead of that the moon's limb, to his surprise, seemed to recede for some three or four seconds of time, and the star disappeared gradually in a sort of luminous haze, through which it was seen with more and more difficulty as it advanced. At the instant of disappearance the star was seen apparently perfectly bisected by the limb; that is, completely shorn of its rays and half

the diffraction disc on the one side (towards the moon), and intact on the other. The explanation given by Mr. Christie seems sound. "The star was not bright enough to be seen distinctly projected on the moon's disc, but was yet not so faint as to be overpowered by the irradiation at the limb. A spurious limb being formed by the superposition of diffraction images, the inferiority of light would increase gradually from the spurious to the true limb. At the former, the star's light overpowered that of the moon; at the latter, the moon's light overpowered that of the star." The circumstance that the diffraction image of the star was completely cut off on the side of the moon at the instant of its disappearance is strikingly confirmatory of this explanation.

A Strange Mistake.—Oddly enough Mr. Christie has allowed a remarkable mistake to appear in a paper which he edits. Messrs. Hirst and Russell, observing the moon at nine in the morning of October 21, the moon being then past her third quarter, imagined they saw a great circular shade (or rather part of such a shade) on the moon's face. Mr. Russell inquires into its possible nature, gravely discussing whether it may not have been the shadow of some unknown opaque globe, or of a very dense comet, between the earth and the sun. In reality the supposed shade was nothing but what can always be recognised when the moon is at that phase, the outline of certain dark seas forming in appearance, at that time, a part of a great circle having an apparent radius equal to nearly three-fourths of the moon's.

Phenomena for the Quarter.—Mercury will be in inferior conjunction with the sun on April 17, at 11 A.M.; at his greatest westerly elongation on May 15, when he will be 25° 40′ west of the sun; and at superior conjunction at midnight June 18. Venus is an evening star all through the quarter, her distance from the sun and her brightness increasing through the quarter, the former, indeed, not attaining a maximum till the middle of July, the latter not till the middle of August. The proximity of Mars and Saturn at the end of June will render these planets interesting objects to telescopists, though Mars will be far less brilliant than when he was in conjunction with Saturn in the autumn of 1877. At 8 P.M., June 30, the distance between the planets will not be more than one minute—a thirtieth, say, of the moon's diameter. But it will not be till a much later time of that night that the proximity of the planets can be favourably observed in England.

CHEMISTRY.

Conversion of Sugar into Alcohol by Inorganic Agents.—While considering the action of fermenting agents, Berthelot has been led to try an experiment which does not exactly solve the question of the conversion of sugar into alcohol by inorganic agents, although it throws some light upon that change. The hypothesis, to follow the consequences of which was of interest to him, was the following. If we assume that the action of a ferment consists in the breaking up into two complementary ingredients, of which the one contains the more oxygen, the other the more hydrogen—an action, in short, closely resembling that of potash on aldehyde—the two products will exhibit

a reciprocal activity. As, however, the energy consumed by the first decomposition cannot be again produced, the pristine sugar cannot be reproduced. In place of this the products suffer a new and deeper decomposition into alcohol and carbonic acid. Berthelot examined the condition of the simultaneous hydrogenation and oxidation of the sugar. A battery of six or eight Bunsen cells was employed, the poles of which were connected with an oscillating commutator which could be alternately positive and negative twelve to fifteen times in a second; and the electrodes were cylinders of platinum black. This apparatus, when immersed in acid water, evolved at each of the poles hydrogen and oxygen alternately. The apparatus was so regulated that it evolved no gas, the water being reformed at the moment after its decomposition. When placed in a watery solution of glucose, which was in some instances neutral, in others acid, and in others alkaline, alcohol was decomposed but only in very small quantities (some thousandths), the greater part of the glucose resisting the decomposition. So limited a change does not justify one in drawing conclusions. The production of alcohol in the cold, however, and by means of sugar, is a fact of great interest.—*Compt. rend.*, lxxxvii., 949.

The Chemical Composition of Sea-water.—Jacobsen has set himself the task of deciding the question whether the composition of sea-water taken from different seas and oceans, and different depths, possessed the same composition, and whether the discrepancies observed in analyses were due to errors of manipulation. For this purpose he examined the composition of forty-six specimens of sea-water, collected on board the "Gazelle" during the expedition of 1874-1876, for every possible locality and depth. The constituents which were determined were chlorine, sulphuric acid, and calcium carbonate. The chlorine showed only a very slight variation; the salt corresponding to the chlorine amounted in the highest case to 1·8140, in the lowest case to 1·8047, the mean being 1·80936. The chlorine was determined in fifteen specimens. When it is remembered that these results are influenced by the unavoidable errors of chlorine determinations and the determination of salt, one will not be disposed to ascribe to the found irregular variations any significance of weight, but will not hesitate to say that the relative amounts of chlorine contained in oceanic waters show no considerable variation. The sulphuric acid was determined in 106 specimens of water. It constituted in the mean 6·493 per cent. of the entire salt present; the greatest difference (0·35 per cent.) lay between the maximum 6·69 per cent. and the minimum 6·34 per cent. The author remarks that here again the variation would be less if the unavoidable error of the areometric determination of salt could be eliminated. There are grounds, however, for believing that the amount of sulphuric acid present in water is somewhat less constant than the amount of chlorine. On the other hand, attention must be directed to the fact that any regular variation in the properties of sulphuric acid, depending on the place or the depth from which the water has been taken, was not observed. The determinations of calcium carbonate were made in thirty-nine samples of water. The mean result was in 10,000 parts of water 0·269 parts of lime carbonate, the maximum being 0·312 parts, and the minimum 0·220 parts. So far from referring these variations in the results to differences in the sources whence the waters were taken, or regarding

them as indications of any other change, the author ascribes them to errors of experiment which became the greater in these cases from the fact of his having a more limited quantity of water to work with (less than one litre) than is desirable for experiments of these kinds. The results are very accordant when compared with the hitherto published analyses. They support the view held by the author that the amount of lime carbonate present in sea-water shows but slight variation. His results do not accord with those of J. Davy, who believed that the open sea contained little or no lime carbonate. And we are, moreover, not driven to believe the views pronounced by Forchhammer, that the sea animals which have shells are able to convert the lime sulphate of sea-water into carbonate. The waters of different regions appear to mix very rapidly and readily.

The Ammonia and Nitric Acid in Atmospheric Deposits.—In the year 1875 at the agricultural station in Munich, and in 1876 and 1877 at Tisis, near Feldkirch in Vorarlberg, W. Eugling made a number of determinations of these constituents in the rain, and the results are given in his report in Biedermann's "Centralblatt für Agriculturchemie," 1878. The amount of combined nitrogen appears from the results to vary considerably according to the locality where the rain was collected; the nitrogen compounds which are brought down to the soil in the immediate neighbourhood of large towns are probably considerably greater. And the amount which fell in the months when the rainfall was small was higher than in months when the aqueous deposit was more abundant. These results confirm those of Boussingault's researches. The average amount of the nitrogen in the precipitates which were collected in Tisis, while lower than that in the Munich deposits, is greater than that of Paris, where in 1858 Boussingault found 0·00163 gramme to the litre. In 1876 the average monthly yield at Tisis was 0·00320 gramme per litre, the maximum yield being in October 0·00620 gramme to the litre, and the minimum 0·00182 gramme per litre in April. In the year 1877, with the exception of September, the mean yield of ammonia was 0·00238 gramme per litre, the maximum being in November 0·00520 gramme, and the minimum in April being 0·00121 gramme per litre. In addition to this, it was found that the amount of nitric acid in 1876, with the exception of December, was in the mean 0·00192 gramme to the litre, the maximum being 0·00431 gramme in October, and the minimum 0·00085 gramme in January; and in the year 1877 the mean yield was 0·00160, the maximum in November being 0·00264, and the minimum in December 0·00092. In the case of Munich the mean for the month of March was 0·00366 gramme of ammonia and 0·00169 gramme of nitric acid per litre; and during April, on the other hand, 0·00414 gramme of ammonia and 0·00185 gramme nitric acid per litre. It was noticed that during those months when the ozone reaction was strongest the amount of ammonia, and nitric-acid-nitrogen were most nearly equal, which points to the conclusion, that at these times more ammonia nitrate and less ammonia carbonate are formed, not absolutely, but in relation to each other.

Formation of Felspars Artificially.—F. Fouqué and M. Lévy have communicated to the Academy of Sciences of Paris, the details of the process by which they have succeeded in preparing a suite of felspars, analogous to those which occur in eruptive rocks. They employ either natural porphy-

rised felspar or artificial mixtures of the chemical constituents, in short silicic acid and alumina, fused carbonate of potash and soda, and ignited carbonate of lime. The mixture is placed in a platinum crucible and heated to a temperature approaching that at which platinum melts in a Schloesing's furnace. The homogeneous mass thus formed, if suddenly cooled, is isomorphous; it must be placed without any delay in the flame of a Bunsen burner with a blast attached to it, and kept there for forty-eight hours at a temperature as little below the point of fusion as possible; and then, without any further precaution, allowed to cool in the crucible. Although the mass while fused occupies but little space, when heated with the blast it gives off bubbles and presents a porcelain-like appearance. Although the pocket-lens fails to detect the presence of crystals in this mass, the microscope shows the material to be made up of crystalline felspar. By this method Fouqué and Lévy have succeeded in preparing crystals of the three varieties of felspar which have the lowest fusing point, oligoclase, labradorite, and albite, in the forms in which they occur in eruptive rocks; and they hope in further experiments to prepare, not only the other simple varieties of this mineral, but the many combinations of them which are known.—*Compt. rend.*, lxxxvii., 700.

The Liquids Enclosed in the Cavities of Topaz.—T. Erard and A. Stelzner have examined the liquids in some cavities of topaz in the following manner. The microscope, the preparation, and a thermometer were all placed in a water-bath and so kept at an even constant temperature. The water was raised to a temperature of 30°, and after, in ten minutes, it had cooled to 28°, it was assumed that microscope, preparation, and thermometer had all the same temperature. The liquid enclosed in a cavity was now examined through the microscope, and warm water was slowly poured in as far removed as possible from the microscope, and carefully mixed up with the other water, while the other observer noted the temperature of the thermometer. When the liquid vanished, the apparatus was allowed to cool, and the return of the liquid observed. Seven cavities in two topazes from an unknown locality were examined. Each cavity contained two fluids; the individual point of limit of each at the lower temperature to which the preparations were exposed remained unchanged. The liquids always vanished suddenly, and their return in each of the seven cases was accompanied by violent boiling. It was found that for one and the same enclosure of the kind referred to the sudden disappearance of the liquid and its equally sudden return with the accompanying boiling took place at one and the same temperature, the difference in the observations, amounting to 0·03°, being evidently within the error of observation. The critical point was found not only to be somewhat different in the case of each preparation, but in the case also of the fluids contained in one and the same cavity. Although the sudden disappearance and return of the liquid took place at temperatures lying between 28°·745 and 29°·18, the fluid in no case can be pure carbonic acid, the critical point of which lies, according to Andrews, at 30°·92. As, however, Andrews has since shown experimentally that an admixture of permanent gases lowers the critical point of carbonic acid, it is probable that the so greatly expanding liquid contained in these cavities is a somewhat impure carbonic acid.—*Mineralogische und Petrographische Mittheilungen*, i., 450.

Contributions to Chemical Dynamics.—Dr. Wright and Mr. Luff have furnished a second report to the Chemical Society on some points in chemical dynamics, and containing an account of some further researches on the influence of time and temperature on the decomposition of metallic oxides by the three agents—carbon, carbonic oxide, and hydrogen. In their earlier report they studied the action of these three substances on ferric and cupric oxides, with the result that, for similar physical conditions of the reacting bodies, the greater the heat-evolution which occurs when the two substances react, the lower is the temperature at which the reaction commences. In the present report Dr. Wright and Mr. Luff investigate the action of carbon, carbonic oxide, and hydrogen on a number of additional metallic oxides, including those of manganese, lead, cobalt, and nickel. They arrive at the following conclusions. In the case of the oxides of iron and copper, which form two definite series of salts, the temperature of initial action of the reducing agents on the two oxides corresponding to these series of salts will be the same for each. This is in accord with the fact that the same amount of heat is evolved in the conversion of a given volume of oxygen into either of these oxides. In the case of the oxides of the metals —manganese, lead, nickel, and cobalt—which form superoxides, not corresponding with definite series of salts, and evolving oxygen on being heated, the temperature of initial action of a given reducing agent on the superoxide of one of these metals is sensibly lower than that of the same agent on the stable monoxide of the same metal. It is probable that this difference indicates that less heat is evolved when a given amount of oxygen unites with the metal to form the superoxide than would be the case if the monoxide was formed, which indeed is known to be the case in connection with one of these metals—manganese. It was also found that the temperature at which carbonic oxide commenced to act on any metallic oxide was invariably less than that required for hydrogen to react; whilst we learn that hydrogen commenced at a lower temperature than required by carbon. The connection which has thus been established between the amount of heat evolved during a reaction and the temperature at which the reaction occurs is a point of very great interest in chemical dynamics, and in the hands of the mathematician may lead to important light being thrown on the true nature of chemical combinations. It points in an obvious manner to an imaginable connection between the velocity of molecular vibration and the attractive force maintaining chemical union. This idea is strengthened by the remarkable fact to which the authors draw attention, that a long-continued exposure of the metallic oxide to the action of the reducing agent will develop a sensible chemical reaction at a lower temperature than will give rise to any action in a few minutes. It is to researches of this nature that we must look for a real extension of our present slight knowledge of the Dynamics of Chemistry.

The Yttrium Group of Metals.—In 1843 Mosander announced that Berzelius's yttria was really a mixture of three earths which he named yttria, erbia, and terbia, and he gave a short account of the characteristics of each base. Yttria was colourless and afforded colourless salts; terbia was also colourless, but gave pink salts; and erbia was dark yellow. Subsequently Berlin, and afterwards Bunsen and Bahr, worked on this subject, but were

unable to find more than two metals in this group which they termed yttrium and erbium (which was really Mosander's terbium). It was therefore generally supposed that there were only two metals in this group, and that terbium did not exist. Last year the subject was taken up by Marignac and anew by Delafontaine. In the early part of last year they both announced that they had found a third substance present besides yttrium and erbium, and agreeing well with the properties of the third metal of Mosander.

The new earth, terbia, is of a pure dark orange colour, but on being heated in a current of hydrogen, or at a high temperature in the open air, it becomes colourless. Its salts are colourless, and have no absorption spectrum. The atomic weight of terbium is 98·5 or 147·7 accordingly as terbia is considered to be a monoxide or sesquioxide. The atomic weight of yttrium and erbium are 58 and 114 (or 87 and 171 if these oxides are regarded as sesquioxides). Delafontaine now announces the presence of a fourth and fifth metal in this group which he has termed Philippium (Pp.) and Decipium (Dp.) respectively. The new metal, philippium, has an atomic weight of about 74 (or 111), and forms a yellow oxide and a series of colourless salts far more soluble than those of terbium, which when concentrated give a very intense absorption band in the indigo blue, a band not visible in the salts of yttrium, erbium, or terbium. The fifth metal, decipium, resembles didymium in its properties, but gives three remarkable absorption bands in the blue and indigo. Later, Delafontaine has been led to suspect the existence of a sixth metal of this group. In the meanwhile, Marignac has announced the discovery of yet another member of this group which he terms ytterbium (Yb). Both its oxides and salts are colourless, and are moderately easily soluble. They do not give any absorption spectrum. The atomic weight of ytterbium is about 115 (or 172·5 if the earth is a sesquioxide), or nearly that of erbium; but if the existence of this new metal be confirmed, it is probable that it will be found that Cleve and Hoeglund's determination of the atomic weight of erbium was vitiated by the presence of ytterbium, and that it ought to be below even Bunsen's value or about 104–5. Chemists will wait with some curiosity to learn whether further investigation confirms the existence of these numerous additions to the group of cerium and yttrium metals.

The Absorption Spectra of Organic Substances.—At the meeting of the Royal Society for January 9, 1879, a paper was read, by Messrs. W. Noel Hartley and A. R. Huntingdon, on the "Absorption of the Ultra-Violet Rays of the Spectrum by Organic Substances." The paper embodies a research which is likely to throw considerable light on the molecular constitution of the organic bodies. The normal alcohols of the fatty series are remarkably transparent to the ultra-violet rays of the spectrum; but there is an increased absorption of the ultra-violet rays corresponding to each increment of CH_2 in the molecule. The acids and the normal ethereal salts derived from the alcohols are highly transparent to the ultra-violet rays. When, however, the benzene derivatives came to be examined they were found to exert an enormous absorption on the extra-violet rays, and when dissolved in water they continued to show marked absorption bands even when very dilute. The isomeric bodies, containing the benzene nucleus,

exhibit widely different spectra, inasmuch as these absorption bands vary in position and in intensity. This widely different behaviour of the benzene and alcoholic compounds is a point likely to prove of service, as, for example, in the study of the constitution of the terpenes.

GEOLOGY AND PALÆONTOLOGY

Toothless Ichthyosaurus.—Those wonderful regions of the western territories of North America from which so many remarkable fossil forms have been derived show no signs of approaching exhaustion. Soon after the discovery of birds with true teeth had startled naturalists, remains of Pterodactyles were for the first time found in America, and these, following the example of the birds, reversed the accepted order of nature by exhibiting toothless jaws. Following up this remarkable series of discoveries, Professor Marsh now announces (*Amer. Journ. Science and Arts*, January, 1879) the occurrence in Jurassic deposits immediately below what have been described as the *Atlantosaurus*-beds, of the remains of a Saurian, presenting in most parts of its skeleton the characteristics of *Ichthyosaurus*, but *entirely without teeth.* He says "the vertebræ, ribs, and other portions of the skeleton preserved cannot be distinguished from the corresponding parts of *Ichthyosaurus*; and many features of the skull show a strong resemblance. The general form of the skull is the same. The great development of the premaxillaries, the reduced maxillaries, the huge orbit, defended by a ring of bony plates, are all present; but the jaws appear entirely edentulous and destitute even of a dentary groove."

The remains of this Saurian, which Professor Marsh names *Sauranodon natans*, preserved in the museum of Yale College, indicate an animal eight or nine feet long, of which the skull, which has the facial portion much produced, makes up about two feet. The orbits are very large, but the sclerotic ring consists only of eight plates, which are not arranged in a nearly flat ring, as in ordinary Ichthyosaurus, but form the basal segment of an elongated cone, as in the eyes of many birds.

Professor Marsh regards this curious creature as representing a special order of reptiles which he proposes to name Sauranodonta. It seems doubtful, however, whether the mere absence of teeth, either in this form, or in the toothless Pterodactyles, is a character of sufficient importance to justify the establishment of a new ordinal group.

Dolerophylleæ, a new order of Carboniferous Plants.—In April last Count Gaston de Saporta established a new genus of fossil Gymnosperms, under the name of *Dolerophyllum*, upon certain large conical buds formerly referred by Professor Göppert to the Musaceæ, and upon some leaves which were previously regarded as leaflets of *Nœggerathiæ* or of ferns. These leaves were allied to M. Grand-Eury's genus *Doleropteris*, which, in his opinion constituted, with *Rhacophyllum* and *Aphlebia*, a group of plants wavering between *Nœggerathiæ* and ferns.

M. de Saporta and M. Renault have investigated these plant-remains, and according to the statements of the former (*Comptes rendus*, September 9,

1878, p. 373) they regard them as forming probably an order, Dolerophylleæ distinct from the Salisburieæ and Cordaïteæ, although specially allied to the latter through certain forms recently described in America by Professor Lesquereux. The leaves, which have generally been mistaken for leaflets of Neuropteroid ferns and described under the names of *Cardiopteris*, *Cyclopteris*, *Nephropteris* and *Aphlebia*, differ clearly in structure from those genera. They are simple, sessile, oval, or rounded, eared at the base, thick, encircled by a cartilaginous border, and traversed by numerous dichotomous nervures, which radiate from the point of attachment towards the margin and often bifurcate several times. The nervures were enclosed between two thick laminæ of epidermis, and are especially characterised by the abundance of gummous ducts, the true structure of which is not yet determined, but which accompany and surround the vascular bundles, often, when carbonised, forming filaments substituted for the true nervures which they conceal. This character recurs, although less strongly marked, in the Cordaïteæ. The insertion-scars produced on the stems by these leaves must have been rounded or transversely ellipsoidal, and such scars occur upon the stems of many so-called Calamodendreæ.

The reproductive organs ascribed to the Dolerophylleæ by M. Renault are very singular; and, while differing much from what are ordinarily observed in Phanerogamia, they indicate the existence of a series of plants in which fecundation was effected by means of corpuscles nearly agreeing, although of much larger dimensions and more complicated structure, with the pollen grains observed in the micropyles or pollenic chambers of several Palæozoic Gymnosperms.

Thus, according to M. de Saporta, the Dolerophylleæ represent in the Carboniferous flora, which was formerly supposed to be so predominantly cryptogamic, a new phanerogamic element; in fact, they were related to a whole series of prototypic phanerogams of which the Sigillarieæ probably also formed a part.

A Gigantic Triassic Reptile from the Cape.—Under the appropriate name of *Titanosuchus ferox* Professor Owen has lately described before the Geological Society a gigantic reptile belonging to his order Theriodontia, derived from the same South African Triassic beds which have already furnished him with so many remarkable and interesting forms of the same class.

He stated that among the fossils recently sent to the British Museum from the Cape of Good Hope by Mr. T. Bain there were two boxes containing specimens of a most unpromising character, there being in them no entire bones, but only numerous more or less water-worn fragments. Among these was found a portion of a maxillary showing some traces of teeth; and sections having been made of this bone, the remains of several teeth were displayed, including a canine, the preserved portion of the socket of which was 4½ inches long. From the number and mode of implantation of the teeth, he concluded that the animal to which they belonged resembled the Theriodont genera *Galesaurus* and *Galenops*. The anterior portion of the left ramus of the lower jaw, measuring 7½ inches in length, showed teeth presenting close analogies with those of Theriodonts, and this alliance was confirmed by the study of other fragments. Some of the characters presented by these remains seem to suggest affinities with the carnivorous mammalia,

such as have been already indicated by the humeri of Theriodonts and Carnivores.

The canine tooth of the new South African reptile was six times as long as that of the allied form *Lycosaurus*; and we have in *Titanosuchus* evidence of a carnivorous reptile of more carnassial type than *Machairodus* and other felines. The author suggests that *Titanosuchus* found its prey in the contemporary *Pareiosauri*, Oudenodonts, and Tapinocephalans of the same locality.

Submerged Forest on Bombay Island.—In Part IV. of the "Indian Geological Survey Records for 1878" is an interesting note on a submerged forest lately discovered on Bombay Island during the excavation for the Prince's Dock. The strata exposed in this excavation consist of some four to five feet of surface silt, superimposed upon a bed of dense blue clay, varying in thickness from 6 to 20 feet, but nearly level on the top; this clay rests upon loam and "moorum" (a local term for decomposed rock), the waste of the rock lying immediately below it. This rock is very irregular on its surface, and consists for the most part of indurated clay nodules imbedded in a hard matrix. It is between this rock and the silt at the surface that the submerged forest has been discovered. The trees grew in the loam and "moorum" in which their roots are found, apparently *in situ*, while the stumps penetrate into the blue clay above, some being in an erect and others in a more or less horizontal position; in no case, however, do they reach into the surface silt. "For a foot or so below the level of the blue clay the timber was riddled by *Teredo navalis*, or a similarly destructive worm," and a trunk was found to be charred on one side for a short distance. The largest trunk found measured 46 feet in length and 4 feet 8 inches in girth; and some of the timber, which is of a dark rosewood colour, with a straight grain, was quite sound. From the fact that the roots of these trees were found at a level of from low-water extreme tides to twelve feet below that line, Mr. Ormiston, the engineer, supposes that the land must have subsided at least thirty feet; but Mr. Blanford suggests that did the trees belong to such forms as *Avicennia* or *Bruguiera*, they might perhaps have grown in a salt-marsh, a supposition supported, he thinks, by the presence of *Teredo* borings in some of the stumps, and that, were this the case, it would materially affect the calculation of the depth to which depression has taken place.

Geology of Minorca and Majorca.—M. H. Hermite gives a description of the geological structure of these two little-known islands (*Comptes rendus*, December 30, 1878). Minorca is divided into two very distinct parts by a line running from N.W. to S.E., or from Mahon to Algairen. South of this line is an undulated plateau with deep ravines, formed of nearly horizontal calcareous strata which abut against the greatly raised strata of the northern region. The latter contains the oldest formations of the Balearic Islands, namely, about 1,000 mètres of grey or greenish schists and sandstones, showing vegetable impressions (*Calamites*), and having towards the middle of the system some calcareous deposits containing fossils belonging to the Middle Devonian. The upper portion of the schists and sandstones, therefore, probably represents a member of the Carboniferous formation. They are followed by fine-grained red or white sandstones with traces of plants, about

500 mètres in thickness and belonging to the Trias. The earliest Jurassic beds belong to the Middle Lias; these are followed by unfossiliferous limestones (sometimes dolomitic); and the uppermost Mesozoic deposits are whitish limestones with Neocomian fossils. All these strata are tilted at a high angle, and against them, as above stated, abut the Middle Miocene limestones which form the greater part of the southern region. Recent calcareous deposits containing *Helix vermicularis* and some fragments of marine fossils attain to a considerable extension, and rest indifferently upon the Miocene and older beds, indicating a great descending movement at the time of their formation.

In Majorca the oldest deposits are red sandstones (Trias), and these are met with only at one spot on the coast. Above these there is the same succession of formations as in Minorca; but the Middle Lias fossils are only found in a few localities. Above this are about 400 mètres of limestones, generally unfossiliferous, which probably represent a great part of the Jurassic strata; at the Puiz de Lope ammonites occur which seem to indicate the presence of the Oxfordian; and the series is crowned by limestones containing Cephalopoda, which indicate the horizon of *Ammonites transitorius*. The Neocomian is greatly developed, and contains a fine fauna. If the older beds are wanting, the Tertiaries, on the contrary, are much better developed than in Minorca. The lowest stage of these is a lacustrine limestone with beds of lignite at its base in some places, which the author regards as of Lower Eocene age: it was thought to be supra-nummulitic by Haime, but is overlain by the Nummulitic limestones. The lake in which these deposits were thrown down was more than 80 kilomètres in its longest diameter.

The Stonesfield Mammals.—It has long been known that in the so-called "Stonesfield slate" of Oxfordshire, a part of the Lower Oolite formation, the remains of mammalia occur; in fact, four species, belonging to three genera, are recorded by Professor Owen. Of these, the most ancient mammals after the *Microlestes* of the Keuper of Württemberg, which is known only from teeth, the only traces hitherto described have been the lower jaws. Professor Seeley has announced to the Geological Society (February 21, 1879) his discovery, in slabs of Stonesfield slate which have been preserved for many years in the British Museum, of two small bones, which, on examination, were found to present mammalian characters. These are a femur and a humerus; and as they nearly correspond in size, and there is no evidence to the contrary, Professor Seeley preferred to regard them provisionally as belonging to the same species, and from their characters he was inclined to associate them with the jaw described under the name of *Phascolotherium*. They are considered by him to indicate a special, probably insectivorous, monotreme type, with marsupial tendencies, such as, on the hypothesis of evolution, might well be supposed to occur early in the history of the mammalia. It is to be hoped that the detection of these interesting remains may lead to a careful examination of the slabs from Stonesfield which exist in many museums, and that the search may be successful.

Conodonts.—The curious minute fossils described by Pander under the name of Conodonts, and regarded by him as probably the teeth of fishes of very low organisation, have been detected in great abundance by Mr. G. J. Hinde in rocks of the Chazy and Cincinnati groups of the Cambro-Silurian,

and of the Hamilton and Genesee-Shale divisions of the Devonian in Canada and the United States. In a paper read before the Geological Society (March 12, 1879) that gentleman described a great number of forms of these bodies, including most of those figured by Pander from Russian Silurian rocks, and some not previously met with. In the Chazy beds they are associated with numerous Entomostracan crustacea of the genus *Leperditia*, a few trilobites, and some gasteropods; in the Cincinnati group they occur with various fossils; and in the Devonian principally with fish-remains; but none of the associated fossils furnish any clue to the true nature of these problematical bodies. Mr. Hinde regards their zoological relationship as very doubtful, but they most resemble the teeth of Myxinoid fishes.

Fossil Remains of Annelids.—At the same meeting of the Geological Society Mr. Hinde described numerous jaws of annelids which he had obtained from Cambro-Silurian, Silurian, and Devonian rocks in Canada, and from the Lower Carboniferous of Scotland. The existence of annelids during the deposition of the older rocks has hitherto been evidenced chiefly by the occurrence of their trails, and of a few impressions of their bodies; the former being a very uncertain ground, seeing that in some cases, at any rate, the supposed annelid-trails have been proved to be the tracks of crustaceans. Of the nature of the fossils described by Mr. Hinde, chiefly obtained from shallow water deposits, no doubt could be entertained; he showed their close resemblance to the jaws of existing annelids, and indeed was enabled from these resemblances to refer them to well-known families. Mr. Hinde enumerated fifty-five different forms of these minute bodies, mostly from the Cincinnati group of Canada; and classified them under seven genera, five belonging to the family Eunicea, one to the Lycoridea, and one to the Glycerea.

MICROSCOPY.

Method of Investigating the Embryos of Fishes.—M. Henneguy has communicated to the Philomathic Society of Paris the description of a method of preparing the embryos of fishes and other similar objects for microscopic purposes. He places the ovum for a few minutes in a 1 per cent. solution of osmic acid until it acquires a light brown tint, and then in a small vessel containing Müller's liquid, in which he opens it with fine scissors, when the central vitelline mass dissolves at once in the fluid, and the solidified germ can be extracted from the ovum for examination. By treating the germ with a solution of methyle-green and then with glycerine he has been able to observe in the cells of segmentation those very delicate phenomena which have been lately described by Auerbach, Bütschli, Strasburger, Hertwig, and others, proving that the treatment to which the ovum had been subjected did not alter the elements of the germ.

For the purpose of making cross-sections of the embryos, M. Henneguy leaves them for some days in Müller's liquid, and colours them with picrocarminate of ammonia. He then treats them with alcohol of spec. grav. 0·828, and afterwards with absolute alcohol to free them from water, and soaks

them for twenty-four hours in collodion. Each embryo is then arranged upon a small plate of elder pith soaked in alcohol and covered with a layer of collodion, and when the latter has arrived at the proper consistency very thin sections may be made through the embryo and the pith. They are to be preserved in glycerine. The process has the advantage of enabling one to see the precise point at which each section is made, and there is no occasion to free the sections from the collodion which encloses and holds them in place.—*Ann. and Mag. Nat. Hist.*, March, 1879.

Preservation of Infusoria.—M. A. Certes has communicated to the French Academy of Sciences (*Comptes rendus*, March 3, 1879) an account of a process which he describes as very successful in the preservation of the Infusoria.—He says that the preparations exhibited in illustration of his note showed "various species of Infusoria, fixed instantaneously in their form: the smallest details, cilia, cirrhi, flagella, buccal armature, can be observed under the highest powers; the green *Euglenæ* and *Paramecia* retain their characteristic colour. The nucleus and nucleolus, coloured artificially, stand out clearly, and show, when these occur, the curious phenomena so well described by M. Balbiani" in 1862. A process offering such results as these is worth knowing; the following is the author's account of it.

For the fixation of the Infusoria he employs osmic acid, either in the form of vapour, or in a solution containing two per cent. of the acid. In the former case the Infusoria placed upon a glass slide may by exposed to the vapour for from 10 to 30 minutes. With very contractile species he places a drop of the solution on the covering glass, before placing it upon the drop of water containing the animalcules. The excess of liquid under the cover is then removed by means of blotting paper, and thus a slight pressure, said to be advantageous, is produced upon the specimens. Two opposite sides of the thin glass are then luted down either with paraffine or with Canada Balsam, and the preparation being thus secured against displacement, the colouring material and the preservative may be introduced. M. Certes mentions soluble aniline blue and eosine as colouring agents, but gives the preference to Ranvier's picrocarminate of ammonia, which he employs combined as follows:

Glycerine	1 part.
Water	1 „
Picrocarminate	1 „

In the introduction of glycerine the author follows the method recommended by Ranvier in his "*Traité d'Histologie.*" He places in a damp chamber the preparations fastened as above described, and puts a drop of the coloured glycerine on the edge of the covering glass. The water evaporates very slowly, and in twenty-four hours the film of water between the glasses is replaced by dilute glycerine, which may in its turn be replaced by concentrated glycerine by the same process. The best varnish for closing these preparations according to M. Certes is dry Canada Balsam dissolved in chloroform.

PHYSICS.

Acoustic Vibrations Caused by Heat.—Lord Rayleigh, in a recent lecture at the Royal Institution, drew attention to some forms of this phenomenon.

After briefly naming Trevelyan's Rockers, Sondhauss's experiment was shown, in which, when a bulb about three-quarters of an inch in diameter is blown at the end of a narrow tube 5 or 6 inches long, a sound is heard proceeding from the heated glass. The original observer showed that the vibration of the glass itself is no essential part of the action.

If a closed tube, hot at the closed and cool at the open end, be considered; if the adjustment of temperature were instantaneous, heat would have no effect in producing vibration. But as it takes time, it follows that at the phase of greatest condensation heat is received by the air, and at the phase of greatest rarefaction is given up from it, so that there is a tendency to maintain the vibrations. A great range of temperature is necessary for the maintenance of vibration, and the transfer of heat is unfavourable at the closed end, where the motion is small. Hence, probably, the advantage of the bulb.

The sounds emitted by a jet of hydrogen burning in an open tube are in a measure due to the column of gas in the tube which supplies the jet. If this be plugged with cotton, no sound can be obtained.

When a piece of fine metallic gauze stretched across the lower part of a tube open at both ends and held vertically is heated by a gas flame placed under it, a sound of considerable power, lasting for several seconds, is observed almost immediately after the removal of the flame. It seems to be due to a draught impinging on the heated gauze.

A complementary phenomenon was discovered by Bosscha and Ries. If a current of hot air impinge on cold gauze, sound is produced, but, to obtain the principal note, the gauze must be in the upper, not in the lower half of the tube.

On the Anatomy of the Organ of Hearing in relation to the Principle of the Microphone.—Dr. J. D. Macdonald, F.R.S., very ingeniously points out the similarity in principle between the vibrating particles of the microphone and the otoconia and otoliths in Pteropods, and others of the lower animals. Even the malleus and incus in the human ear "correspond not only in figure, but also in function, to the objects from which their respective names are derived, answering very important ends in the faculty of audition." Dr. de Chaumont notes the influence of moisture as in Mr. Blyth's experiments. The *otoconia*, *endolymph*, and *vestibule* of the ear present a complete type of a microphone.

The Electrical Gyroscope.—The value of the gyroscope as a means of showing the earth's rotation independently of any astronomical observation, seems hardly to have been appreciated. This, and another noble experiment for the same purpose by means of a long pendulum, are due to the ingenuity of the late Mons. Foucault. The latter was freely demonstrated at the time of its first announcement in many of our large public buildings, especially in the Radcliffe Observatory, at Oxford. Its simple relation to the sine of the latitude of the place of observation renders it the more valuable. But hitherto there has been some difficulty in showing the more compact form of the same physical law which the gyroscope furnishes. Mons. Foucault himself attained the necessary end of a durable rotation of the heavy disc by means of excellent mechanical construction and the avoidance of all unnecessary friction. In the Loan Exhibition at South Kensington one of his original

instruments lay unheeded in a dark and solitary corner. Had this ill-used and ill-appreciated nucleus of an English *Conservatoire des Arts et Métiers* continued longer, this and many other historical instruments of inestimable value, would in time have received due attention.

The disc was furnished with a small driving pinion, and being removed from its delicate suspension, was dropped on the top of a vertical mill or driving apparatus of multiplying wheels, terminating in a handle. It was thus whirled up to a high velocity, and then gently lifted off the driving apparatus into its position of suspension. The rotation thus imparted could be sustained for above an hour, and even more in a fair vacuum. But from the first it was essentially moribund; and it is only recently that an attempt has been successfully made to render it self-supporting. The machine consists essentially in a wheel of very heavy rim, freely supported on screw points. If the frame in which the wheel turns be itself suspended in a second frame, so that the axis is unconstrained, the position of original rotation will be maintained independently of the motion of the earth. The effect of gravity in tending to keep the disc in a fixed position, relative to the earth's surface, is in fact annihilated. A hand fixed to the frame in which the wheel revolves will move over a divided circle attached to the base of the instrument with an angular velocity equal to 360° multiplied by the sine of the latitude of observation.

It has been ingeniously suggested to apply this motive power by means of electricity. Clockwork and weights or springs are evidently inadmissible. Mr. G. M. Hopkins has overcome constructive difficulties, and rendered the instrument of great practical value.

The disc carries a soft-iron armature close to the face of a small electro-magnet included in the frame. An insulated contact-spring is arranged to touch twice during each rotation, and to cause attraction of the armature. One battery connection is made through the supporting pivot, the other by means of a wire dipping in a ring-shaped mercury cup. Two or three Bunsen's cells are sufficient to maintain rotation at the necessary velocity.

Dilatation by Electricity.—Mons. Duter drew the attention of the *Académie des Sciences* to the fact that when a Leyden jar is formed of a long tube, encased in tinfoil, and filled with water or a saline solution, on its receiving an electrical charge the level of the contained fluid sinks appreciably; on discharge it instantly resumes its former level. The natural conclusion is, that the glass of the jar dilates. This phenomenon occurs whatever be the nature of the armatures, foil, water, or mercury. If the jar thus formed be placed in an outer tube containing fluid, and acting as an outer coating, the latter ascends, while the former sinks. On discharge they both return to their former level. It is, therefore, obvious that internal capacity and external volume increase during the charge of a Leyden jar. The phenomenon cannot be due (1) to rise of temperature, as it suddenly disappears on discharge; nor (2) to electric pressure, which, being the same on the two faces of the dielectric, would tend to diminish its volume; nor (3) to the superior attraction of the electrified jar for the liquid, since it ought, in this case, to sink in the outer jar also; nor (4) to differences of the positive and negative armatures, for if the communications be reversed the direction remains unchanged. The cause seems to be unexplained.

The Microrheometer.—Mr. J. B. Hanway gives the above name to an instrument for measuring the phenomena of the flow of liquids through capillary tubes, which has been termed "transpiration," a word already applied to a totally different process occurring in gases, but for which he proposes to substitute the term "microrheosis," which has the defect of being somewhat hazy in its etymology. The apparatus is so arranged that when the liquid is introduced the pressure and temperature, as well as the atmosphere in which the experiment is conducted, may be varied, while the thermometer is at the mean point of the system. The determination of the relation between the chemical composition of a liquid, as well as its temperature and its rate of flow through a capillary tube, was originally worked out with great accuracy by Poiseuille as regards pressure and dimensions of tube. In examining saline solutions he used percentages instead of equivalent values of the body dissolved, and in consequence could make nothing of the numbers arrived at. Water runs about five times as quickly at 100° C. as at 0°. Mr. Hanway gives a curve for water from 0° to 100°, the differences of rate being smaller as the temperature rises.

In saline solutions the rate of flow does not depend on any of the mechanical features of the salt, such as crystalline form, specific volume, solubility, &c., but on the mass of the elements forming the substance, and the amount of energy expended in its formation. Each element has a value of its own, which is continued in all its compounds. The greater the combining value of an element the higher its rate. The flow also varies with the amount of energy in the compound; thus nitrates stand highest, then chlorides, and lastly sulphates.

Measurement of Powerful Electric Currents.—Mr. John Trowbridge, of Harvard University, contributes a paper on this subject to the American Academy of Science. He divides the methods into four—1, the galvanometric; 2, the electrometric; 3, the thermal; and 4, the electrodynamometric. No. 1 requires the galvanometer to be shunted by a wire of very small resistance. Any error in measuring this small quantity, and any heating of the shunt itself, multiply the whole observations by these errors; indeed, a large quantity is measured by operating on a small fractional part, the hundredth or the thousandth part of itself. Method No. 2 takes the difference of potential of two points in a closed circuit, and is liable to leakage and want of constant charge in the electrometer. No. 3 depends on the law that the heat developed in a circuit $= C^2Rt$, and C can be deduced from measuring the rise of temperature in a given volume of water. It is liable to errors of conduction, radiation, and of thermometers.

Method No. 4 employs Weber's well-known electrodynamometer, consisting of a movable coil hung from a bifilar suspension which conducts the current, between fixed coils on either side of the movable one. But such an instrument, as ordinarily constructed, would be quite incompetent to convey the large currents to be tested without heating and disorganisation. Shunts, as above stated, are to be avoided.

The instrument actually used is described. The large fixed coils are of copper band, thirty-five mm. broad and one mm. thick, in six turns each, insulated with vulcanite, and left their own thickness apart, so as to allow a free circulation of air. The current was not sent through the bifilar suspen-

sion, which could, therefore, be made of silk. The movable coil is at the centre of a rod carrying at the top a mercury cup, and dipping into another by its lower point. Both these were kept cool by a free circulation of water, as in the "tuyères" of a blast furnace. No difficulty from heating was experienced even with currents of 80 Webers. The resistances were large bands of German silver of the value of 1-10th of an Ohm.

With this apparatus the Wilde, Gramme, and Siemens machines were compared, with the result of placing the Gramme first, the Siemens second, and the Wilde third in efficiency, although theoretically the Siemens should give the best result; but it suffered the disadvantage in these experiments of being run at a less speed than the others.

Absolute Pitch.—An ingenious method for determining this was recently brought before the Musical Association by Lord Rayleigh. It depends on the principle that the absolute frequencies of vibration of two musical notes can be deduced from the interval between them, i.e., the ratio of their frequencies, and the number of beats which they occasion in a given time when sounded together. For example, if x and y denote the frequencies of two notes whose interval is an equal temperament major third, we know that $y = 1{\cdot}25992x$. At the same time the number of beats heard in a second, depending on the deviation of the third from true intonation, is $4y - 5x$. In the harmonium these beats are readily counted with the aid of a resonator tuned to the common overtone, and thus are obtained two equations, from which the absolute values of x and y may be found by the simplest arithmetic.

This method is not, however, practical in the case of the harmonium, in consequence of the pitch not being sufficiently constant, even when the blowing is carefully conducted with the aid of a pressure-gauge, the slightest change of interval being fatal to success.

It is, therefore, necessary to be able to check the accuracy of the interval supposed to be known, at the same time that the beats are being counted. The equal temperament whole tone is intermediate between the minor and the major tone, lying nearer to the latter. Regarded as a disturbed major tone, it gives slow and, as a minor, comparatively quick beats. Both can be heard at the same time, and, when counted, give the means of calculating the absolute pitch of both notes. If x and y be the frequencies of the notes, a and b those of the slow and quick beats—

$$9x - 8y = a$$
$$9y - 10x = b$$

whence

$$x = 9a + 8b$$
$$y = 10a + 9b$$

This method in no way assumes the truth of the equal temperament whole tone. Four experiments are given in detail. The author believes that very accurate results might be obtained by the introduction of certain modifications. It is, however, impossible for one observer to count both sets of beats at the same time, or even one, without the aid of resonators.

Further attempts at accuracy would be useless, for the cause above named, unless the comparison with a tuning-fork were simultaneous with the other observations; and more observers would thus be required.

Reflection and Refraction.—Within the last few years Professor J. Clerk-Maxwell has shown the possibility that all electrical phenomena are due to pressures in the same ether, and this has long been assumed as the means of the propagation of light. Acting upon this assumption, he has deduced what the laws of transmission of light in ordinary crystalline and magnetised media would be, and from such deductions he arrived at the laws of these phenomena. In a paper recently read before the Royal Society, Mr. G. F. Fitzgerald, F.T.C.D., investigates the laws of the reflection and refraction of light upon the same assumption, and he has obtained the same results as Professor M'Cullagh long ago deduced from his theory, and which are known to represent almost exactly the laws of reflection and refraction at the surfaces of ordinary and crystalline media. Still further, he investigated the laws of reflection at the surfaces of magnets, with theoretical results which essentially agree with and completely confirm Mr. Kerr's recently published experiments on the reflection of light from the pole of a magnet.

The Magic Mirror of Japan forms the subject of a communication recently made to the Royal Society by Profs. Ayrton and Perry.

Its distinguishing property is that of "apparently reflecting from its polished face the raised characters on its back."

The mirror is of bronze, convex, polished with a mercury amalgam, and bearing at its back a raised design.

Sir Charles Wheatstone, in 1873, appears to have noticed the instrument, supposing that the maker "scratched a pattern on the surface, which, after being polished, showed no traces of the scratches when looked at directly; but when used to reflect the sunlight on to a screen revealed the pattern as a bright image."

As early, however, as 1832, Mr. Prinsep had given an account of the mirror in the "Journal" of the Asiatic Society of Bengal, concluding that "the thin parts are slightly convex with reference to the rest of the reflecting surface," and thinks it probable that "part of the metal was by stamping rendered in a degree harder than the rest, so that in polishing it was not worn away to the same extent."

Various explanations had been offered by Mr. Highley, Sir D. Brewster, and others. Even the Roman writer Aulus Gellius appears to have been acquainted with the instrument.

The authors of the paper saw that the employment of beams of light of different degrees of convergence or divergence would furnish a test for deciding the cause of the whole action. Molecular differences of surface would be practically independent of these factors; whereas if the effect were due to portions of the surface being less convex than the rest, a complete inversion of the phenomenon might be expected to take place under proper conditions. This was found to occur.

The method of producing this distortion by means of an iron rod is explained at length.

Self-luminous Clock Dials.—Dr. Henry Morton, President of the Stevens Institute of Technology, publishes interesting details on this subject. He has made an analysis of the substance with which the dials are coated, and found it to consist of the well-known phosphorescent compound, sulphide of

calcium, attached by means of some resinous medium, like varnish. While the material is far from novel, its method of manufacture and consequent condition give it such intensity as has never been approached before. The light given out is a violet-blue, like that which Becquerel produced with arragonite. Some portions glow by phosphorescence much more brightly than others; evidently this difference depends upon small structural or molecular variations. If further advances be made in this direction wonderful results may accrue. Thus, if walls were painted with such a substance they would absorb light enough during the day to continue luminous all night, and render all sources of artificial light useless. The colouring of houses on the outside with a like material would also evidently obviate the need of street-lamps. He does not expect that this remarkable and economical source of light will displace gas and all other sources of artificial illumination, but this new form of the phosphorescent sulphide of calcium, made of the cheap materials sulphur and lime, is a truly wonderful substance, which may well suggest strange possibilities for the future. In the cabinet of the Stevens Institute are numerous specimens of phosphorescent powders—sulphides of calcium, barium, and strontium—which represent the best products heretofore obtained. These, if exposed to strong sunlight or to an electric discharge, will glow for many minutes in the dark. One of these clocks, however, he found, would continue to glow with sufficient brightness to be visible across a room all night, and could be read at any time, if approached closely. After being shut up in a box for five days this clock was still visible in total darkness, when the eyes had been rendered sensitive by remaining in the dark for a few minutes. This clock-dial is also readily "excited" by lamplight or gaslight, or indeed by any source of light containing rays above the yellow of the spectrum. The light from a Bunsen burner with soda in the flame, if filtered through yellow glass, will not excite it, but the blue rays of the Bunsen-burner flame will. The cause of the action is believed to be somewhat as follows:—When light falls on certain bodies its vibrations cause molecular changes which are not permanent, but are only maintained by the action of the "exciting" vibrations, somewhat as a mass of plastic substance can be kept in a soft condition by constant stirring. When the exciting cause is removed the molecules return to their normal positions, and in so doing set up vibrations which are the cause of light, very much as the solidifying of water evolves heat. Thus these bodies, when exposed to daylight, absorb as it were the light energy, and re-emit the same afterwards. The phosphorescent property of sulphide of calcium has been known since 1768, when Canton prepared it by heating together intensely for an hour three parts of calcined oyster-shells and one part of sulphur. Its properties in this relation have been elaborately studied by Becquerel, who published his researches in the "Annales de Chimie et de Physique," and has also devoted a large part of the first volume of his book, "La Lumière," to this subject. He found that by employing lime in different forms, such as Iceland spar, marble, oyster-shells, arragonite, &c., products emitting different colours by phosphorescence, such as orange, yellow, green, blue, and violet, were obtained.

Collimator Adjustment.—Mr. A. Schuster suggests to the Physical Society a simple means of adjusting the collimator of the spectroscope; the ordinary

process of focussing the telescope to a distant object, and the collimator to the focus so obtained being only applicable to the mean rays, and useless with quartz lenses and ultra-violet undulations. It consists of consecutive approximations. If the collimator be out of adjustment, there will be two positions of the prism, one on either side of the minimum deviation, which will bring the desired ray into the field (A and B).

In position A the telescope is to be focussed to distinctness; in position B, the collimator. After three or four trials no change of focus is required, and the adjustment is made.

Theoretically, the method requires absolutely plane faces to the prism, which are difficult to obtain; but practically the change of adjustment thus required is very small, not amounting to more than one-half per cent. for an exceptionally bad specimen.

The Acoustics of Auditoria.—Mr. W. W. Jacques contributes to the Journal of the Franklin Institute some facts of considerable value on this neglected subject.

The first is a laboratory investigation into the effect of currents upon a ray of sound; the second and third studies, by different methods, of the effects of currents of air in a hall or theatre upon the waves of sound.

At a point A was placed a source of sound, and at E the ear. Between these were placed substances heated so as to produce currents of air corresponding in density to those found in an auditorium. With a small leaden organ-pipe the intensity was increased, but the distinctness impaired. The same effect occurred with a clear voice, accompanied by a sensation of repetition. On the violin the effect was less, and with a drum *nil.*

In the second experiment the sound-waves were actually traced out in space, and their confusion consequent on introduced currents of air demonstrated. A platform 6 feet wide and 12 feet long was set on end in a room 92 feet long by 65 feet broad. On one side was a B_1 stopped organ-pipe, blown with a constant pressure of air.

Within the sound-shadow of this screen a system of co-ordinates, in a plane parallel with the floor, was set up by means of light rods divided into centimètres.

It had been shown by the author that rays of sound diverging from such a source, diffracted round the edges of the screen, on meeting after having passed through paths differing by half a wave-length, will neutralise each other and produce comparative silence. By moving an unison resonator along these co-ordinates the points of interference are easily detected, and are found to be situated as those of the diffraction of light. This was done in a closed room with still air. The doors and windows were then thrown open, and stove registers allowed to admit streams of air at nearly 100° C. The diffraction phenomena instantly disappeared.

The theory thus corroborated was applied to the Baltimore Academy of Music, which is specially arranged to prevent the formation of air-currents of unequal density. The whole supply of fresh air is admitted at the back of the stage, warmed, and led across it to the proscenium diagonally towards the roof, passing into the ventilating tower over the great chandelier at the rate of about 15,000 feet per minute. The room is singularly easy to speak and sing in.

Experiments were made by reversing the ventilating valves, and these showed distinctly that good or confused hearing depended very materially on the amount and direction of the air-currents circulating in the area.

Electromagnetic Rotation of the Plane of Polarisation in Vapour of Sulphide of Carbon has been investigated by Kundt and Röntgen. Faraday failed to detect this phenomenon in gases generally. An iron tube was closed at the ends by glass plates and surrounded with a steam-chamber. This latter was enclosed in six large coils of wire traversed by the current from sixty-four large Bunsen cells. The temperature was then raised to that of boiling water, and a pencil of polarised light was extinguished by a Nicol's prism as analyser. On passing the current the field brightened distinctly, and still more by commutation of the current. This rotation followed the direction of the positive current, and amounted to about 30′ of arc.

The same rotation was afterwards observed in gaseous sulphurous acid at 10° C., and at a pressure of twenty atmospheres; also in sulphuretted hydrogen at the same pressure, and at the ordinary temperature. Air up to twenty-five atmospheres gave no results.

Velocity of very Loud Sounds.—Mr. W. W. Jacques communicates some experiments on this subject to "Silliman's Journal," from which it appears that—

(1) The velocity of sound is a function of its intensity.

(2) Experiments in which a cannon is used contain an error, probably due to the bodily motion of the air near the cannon. A low musical sound should be used for determinations of velocity.

A Current Regulator.—Dr. Siemens brought before the Royal and Physical Societies an instrument of this character, depending for its action on the heating effect of the current. In the earlier form of apparatus a fine strip of metal, rolled very thin, was attached at one end to a rigid support, carried over a pulley, and fixed at its other extremity to a lever connected with a series of contact pieces joined to resistance-coils.

In the later form a similar strip of mild steel was stretched across the bottom of a cylindrical box, carrying in the middle a sliding bar or pin resting by its end vertically on the strip. According to the expansion of the strip by the heat of the current, the pin is depressed or elevated, and a circular series of short resistance-coils is introduced one by one into the circuit. The included resistance is thus increased by a rise and diminished by a fall of temperature in the sensitive slip. Dr. Siemens, in describing this compensating action, said: "Suppose that the current intended to be passed through the instrument is capable of maintaining the sensitive strip at a temperature of, say, 60° C., and that a sudden increase of current takes place, in consequence either of an augmentation of the supply of electricity, or of a change in the extraneous resistance to be overcome, the result will be an augmentation of temperature, which will continue until a new equilibrium between the heat supplied and that lost by radiation is effected. If the strip is made of metal of high conductivity, such as copper or silver, and is rolled down to a thickness not exceeding 0·06 mm., its capacity for heat is exceedingly small; and its surface being relatively very great, the new equilibrium between the supply of heat and its loss by radiation is effected almost instantaneously. But with the increase of temperature the position of the regulating lever

is simultaneously affected, causing one or more contacts to be liberated, and as many additional resistance-coils to be thrown into circuit; the result being that the temperature of the strip varies only between very narrow limits, and that the current itself is rendered very uniform, notwithstanding considerable variation in its force, or in the resistance of the lamp, or other extraneous resistance which it is intended to regulate."

PHYSIOLOGY.

The Venom of Serpents.—The poison of serpents has generally been regarded as a sort of poisonous saliva, acting after the fashion of soluble ferments. M. Lacerda, of Rio de Janeiro, has made some observations upon the venom of a rattlesnake, which lead him to believe that this fluid contains formed ferments analogous to the Bacteria. (*Comptes rendus*, December 30, 1878.) Placing a drop of the poison upon a glass slide previously washed with alcohol, and slightly warmed, he examined it under the microscope, and saw "a sort of protoplasmic filamentous matter, formed by a cellular aggregation, arranged in an arborescent form, like that of certain Lycopodiaceæ." He observed the formation of spores within a thickened filament, which finally broke up and disappeared, setting free the spores, which then affected a linear arrangement. He describes the modes of multiplication of these spores, namely, by scission and by interior nuclei.

The phenomena observed in the blood of animals killed by the bite of the snake were as follows:—The red globules presented small bright points on the surface of the disc; these sometimes formed projections, and became more and more numerous. Finally, the globule was completely destroyed, and replaced by a number of very brilliant ovoid corpuscles, endowed with spontaneous oscillatory movements; these ovoid corpuscles did not separate from the mass of the globules, but remained within it, and the globules became fused together to form a very different amorphous paste. Alcohol swallowed, or injected beneath the skin, was found to be the best antidote.

Function of the Chlorophyll in Green Planariæ.—M. P. Geddes has experimented on a green *Planaria*, which is very abundant at Roscoff, with the view of ascertaining what is the function of the chlorophyll, which has long been known to exist in such worms. The *Planariæ* were fond of exposing themselves to the light on the bare sand in shallow water, and when placed in a small aquarium they went always towards the side from which the light came. When exposed to the sun their movements were considerably accelerated, and in a few minutes small bubbles of gas appeared here and there, and increased in number and in volume, just in the same way as with a green seaweed under similar circumstances. The gas evolved was easily collected, and in the course of the day enough was obtained to fill a small test-tube, and it appeared to be dilute oxygen by its effect upon a nearly extinguished match. By further experiments with potash, it was found to contain very little carbonic acid; and the addition of pyrogallic acid showed the presence of oxygen by the dark brown coloration produced and the ascent of the liquid in the tube. M. Geddes found that the gas produced by these *Planariæ* contained 45–55 per cent. of oxygen. The

influence of light is so essential to the existence of these animals, that after being kept in the dark they soon died. Treated with alcohol, these green *Planariæ* furnished first a yellow solution, and then a solution of chlorophyll of a magnificent green colour. The residue, coagulated and decolorised by alcohol, boiled in water and filtered, furnished a clear solution, which, treated with iodine, gave a dark blue coloration, indicative of the presence of a considerable quantity of starch.—*Comptes rendus*, December 30, 1878.

ZOOLOGY.

A Gigantic Deep-Sea Isopod.—Under the name of *Bathynomus giganteus*, M. Alphonse Milne-Edwards describes (*Comptes rendus*, January 6, 1879) an Isopod Crustacean of enormous size, dredged by Mr. Alexander Agassiz from a depth of 955 fathoms north-east of the bank of Yucatan. This animal is nearly ten inches long and four inches broad, and belongs to the great family Cymothoadæ. The most interesting point in its construction is to be found in its respiratory apparatus. The ordinary Isopods have the abdominal limbs modified to form branchiæ, but such an arrangement being apparently insufficient for this comparatively gigantic form, the abdominal feet are converted into a sort of opercular apparatus beneath which are the true branchiæ, which resemble little bushes springing from stems, dividing again and again, a structure of the respiratory organs which is quite unique among the Isopod Crustacea, although one or two forms belonging to the parasitic family Bopyridæ have branched appendages attached to the sides of the body. The position of the eyes is also peculiar. These organs, which are of remarkably large size and each composed of about 4,000 square facets, are placed on the lower surface of the head, instead of the upper surface as in the allied forms.

Mouthless Medusæ.—M. Mereschkowsky has published some curious and interesting observations made by him on two small naked-eyed Medusæ of the genus *Bougainvillea* inhabiting the White Sea (*Ann. and Mag. Nat. Hist.*, March, 1879). He describes one of these under the name of *Bougainvillea paradoxa*, as a small transparent bell about $\frac{1}{25}$ inch long, having four radiating canals, each with a red ocellus and a tuft of from three to seven tentacles at its extremity, while in the centre there is a red manubrium or stomachal peduncle with its mouth surrounded by four much-branched tentacles. The ova are developed on the surface of the manubrium, to which they remain attached for some time. Associated with these normally constructed individuals M. Mereschkowsky found Medusæ of precisely the same size and form, and showing the four canals, with their ocelli and tufts of tentacles, in fact, so far as the characters of the bell were concerned precisely identical with the others, but differing from them in the total absence of the manubrium. There was no trace of any such organ, and the four radial canals met at the summit of the bill without constituting anything that could be interpreted as a stomach. Precisely the same anomaly was observed in the second species, which is a little smaller, and is further distinguished by having the bell more globular in its lower part, but forming above a sort of cupola which renders its form very elegant. In both species the author was unable to detect anything in the shape of a stomachal cavity,

nor could he discover any direct means of communication between the vascular system and the sea-water, any aperture, however minute, through which nutritive material might have been introduced into the system of the animal, and after careful investigation he was forced to the conclusion, that these anomalous little creatures were nourished by the direct absorption through the ectoderm of organic material dissolved in sea-water. This is however, not altogether an isolated case, as M. Mereschkowsky has demonstrated that in certain sponges nourishment is effected in a similar fashion. As several of these little Medusæ occur about our own coasts, it would be an interesting point to ascertain whether any of them present analogous phenomena, and if possible to ascertain why a structure necessitating so abnormal a method of nutrition occurs.

Migrations of Aphides.—M. Lichtenstein has announced his discovery of some very curious facts in the life-history of certain aphides (*Comptes rendus*, November 18, 1878). He first detected migrations of *Phylloxera quercus* from *Quercus coccifera* to *Quercus pubescens*; and these observations were confirmed by those of M. Targioni Tozzetti upon *Phylloxera florentina*, which passes different stages of its life upon *Quercus ilex* and *Quercus pedunculata*.

M. Lichtenstein has since found that the aphis of the galls of the Pistachio (*Anopleura lentisci*) passes from those galls to the roots of at least two species of grasses (*Bromus sterilis* and *Hordeum vulgare*). He describes the development of the aphis somewhat as follows:—

In May and June the *egg* deposited on the pistachio by the fertilised female produces an apterous insect, the *Founder* (first larval form) which produces the gall, and after four moults gives birth asexually to young aphides destined to acquire wings and, after four moults, to produce the *Emigrants* (second larval form) which quit the gall, fly to the grasses, and there produce asexually apterous young, the *Budders* (third larval form), which breed asexually underground, producing several apterous generations until the appearance of nymphs which furnish the *Pupifera* (fourth larval form) which issue from the ground and fly to the Pistachio, where they deposit their pupæ which produce sexual individuals, the females of which deposit the true eggs constituting the starting point of the whole series. If this complicated development be correctly described, it is of much interest, as it may apply to many other species of aphides, and in that case would throw important light upon many points in their history.

The Gymnotus.—From an examination of a fresh specimen of *Gymnotus electricus* M. Fritsch concludes that this fish is allied to the siluroids rather than to the eels. He founds this opinion especially upon the structure of the brain, which has the olfactory tubercles small and the cerebellum very large, as in the Siluroidei; whereas in the true eels these parts present exactly the opposite character. Further, in the *Gymnotus*, as in the siluroids, the maxillaries are rudimentary, and the margin of the upper jaw is formed by the intermaxillaries; in the Muræenoids, on the contrary, the maxillaries form parts of this margin and bear teeth. The structure of the opercula constitutes another agreement with the Siluroids. From a consideration of these and other characters M. Fritsch is inclined to place the Gymnotini close to the Malapterurini, which also include an

electrical species. The denomination "Electrical Eel" thus becomes a misnomer for the *Gymnotus.—Sitzungsberichte der Gesellsch. naturforsch. Freunde zu Berlin*, 1878.

Sir John Lubbock on Ants.—Sir John Lubbock read two papers on ants at the Linnean Society on February 6. The first gave an account of their anatomy; but, from the extreme complexity of these interesting little creatures, it would be impossible to make this communication intelligible without the figures. The second paper was a continuation of his observations on the habits of ants. He mentioned that he had at first isolated his nests by means of water. This was effectual enough, but, especially in summer, the water required to be continually renewed. Kerner, however, had suggested that the hairs of plants served to prevent ants from obtaining access to the honey, and it accordingly occurred to him that strips of fur arranged with the points of the hairs downwards might answer his purpose. He had tried this; and finding it successful, he thought a similar arrangement might perhaps be found useful in hot countries.

It is generally stated that the queen ants alone lay eggs, but Sir John has found that in most of his nests some few of the workers are capable of doing so. It appears, however, that these eggs always produce males. In the case of bees we know that the queen is fed on a special kind of food. In ants it is not possible to make observations similar to those by which in bees this has been established. It is, however, rendered more than probable by the fact that while males and workers have been bred by hundreds in his nests, no queen has yet been produced.

It is well known that ants keep other species of insects in their nests, which they use just as we do cows, &c.

The "Mat. p. l'Hist. prim. de l'Homme" for 1869 contains a short but interesting account by M. Lespes of some experiments made by him on the relations existing between ants and their domestic animals, from which it might be inferred that even within the limits of a single species some communities are more advanced than others. He found that specimens of the blind beetle, *Claviger Duvalii*, which always occurs with ants, when transferred from a nest of *Lasius niger* to another which kept none of these domestic beetles, were invariably attacked and eaten. From this he infers that the intelligence necessary to keep *Clavigers* is not coextensive with the species, but belongs only to certain communities and races, which, so to speak, are more advanced in civilisation than the rest of the species.

Sir John Lubbock, however, removed specimens of the curious *Platyarthrus* from one nest to another, but they were always amicably received. He even transferred specimens from a nest of *Lasius flavus* to one of *Formica fusca*, with the same result.

As regards the longevity of ants he has now two queens of *F. fusca*, which seem quite in good health, and which have lived with him since 1874; they are therefore probably five years old. He has also workers of *Lasius niger*, *Formica sanguinea*, *F. fusca*, and *F. cinerea*, which he has had under observation since 1875.

In his previous papers he had given various instances which seem to show that ants do not exhibit such unvarying kindness to their friends as has been usually supposed. He wished to guard himself, however, against being sup-

posed to question the general good qualities of his favourites. In fact, ants of the same nest never quarrel among themselves; he had never seen any evidence of ill-temper in any of his nests. All is harmony. He had already in previous papers given various instances of tender kindness. Again, in one of his nests of *Formica fusca* was a poor ant which had come into the world without antennæ. Never having previously met with such a case, he watched her with great interest, but she never appeared to leave the nest. At length one day he found her wandering about in an aimless sort of manner, and apparently not knowing her way at all. After a while she fell in with some specimens of *Lasius flavus*, who directly attacked her. He then set himself to separate them, but she was evidently much wounded, and lay helplessly on the ground. After some time another *Formica fusca* from her nest came by. She examined the poor sufferer carefully, then picked her up tenderly, and carried her away into the nest. It would have been difficult, Sir John thinks, for anyone who witnessed this scene to have denied to this ant the possession of humane feelings.

It is clear, from the experiments recorded in the present and in Sir John's former papers, that the ants recognise all their fellows in the same nest, but it is very difficult to understand how this can be effected. The nests vary very much in size, but in some species 100,000 individuals may probably be by no means an unusual number, and in some instances even this is largely exceeded. Now, it seems almost incredible that in such cases every ant knows every other one by sight; neither does it seem possible that all the ants in each nest should be characterised from those of other nests by any peculiarity. It has been suggested in the case of bees that each nest might have some sign or password. The whole subject is full of difficulty. It occurred to Sir John, however, that experiments with pupæ might throw some light on the subject. Although the ants of every separate nest, say of *Formica fusca*, are deadly enemies, still if larvæ or pupæ from one nest are transferred to another, they are kindly received and tended with, apparently, as much care as if they really belonged to the nest. In ant warfare, though sex is no protection, the young are spared—at least when they belong to the same species.

Moreover, though the habits and dispositions of ants are greatly changed if they are taken away from their nest and kept in solitary confinement, or only with a few friends, still under such circumstances they will often carefully tend any young which may be confided to them. Now, if the recognition were effected by means of some signal or password, then, as it can hardly be supposed that the larvæ or pupæ would be sufficiently intelligent to appreciate, still less to remember it, the pupæ which were entrusted to ants from another nest would have the password, if any, of that nest, and not of the one from which they had been taken. Hence, if the recognition were effected by some password, or sign with the antennæ, they would be amicably received in the nest from which their nurses had been taken, but not in their own.

He therefore took a number of pupæ out of some of his nests of *Formica fusca* and *Lasius niger*, and put them in small glasses, some with ants from their own nest, some with ants of another nest of the same species. The results were that thirty-two ants belonging to *Formica fusca* and *Lasius niger*,

removed from their nest as pupæ, attended by friends and restored to their own nest, were all amicably received. What is still more remarkable, of twenty-two ants belonging to *Formica fusca*, removed as pupæ, attended by strangers and returned to their own nest, twenty were amicably received. As regards one, Sir John was doubtful; the last was crippled in coming out of the pupæ case, and to this, perhaps, her unfriendly reception may have been due. Of the same number of *Lasius niger* developed in the same manner from pupæ tended by strangers belonging to the same species, and then returned into their own nest, seventeen were amicably received, three were attacked, and of about two Sir John felt doubtful.

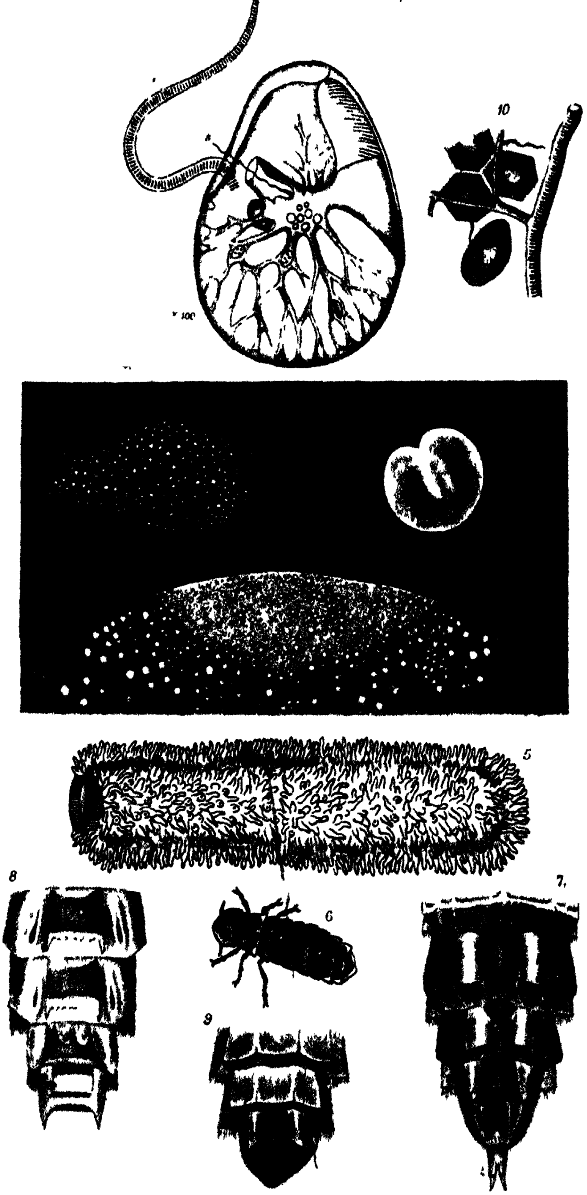
On the other hand, fifteen specimens belonging to the same species, removed as pupæ, tended by strangers belonging to the same species, and then put into the strangers' nest, were all attacked.

The results may be tabulated as follows:—

	Pupæ brought up by friends and replaced in their own nest.	Pupæ brought up by strangers. Put back in own nest.	Put in strangers' nest.
Attacked	0	7*	15
Received amicably	33	37	0

Sir John intends to make further experiments in this direction, but the above results seem very interesting. They appear to indicate that ants of the same nest do not recognise one another by any password. On the other hand, if ants are removed from the nest in the pupa state, tended by strangers, and then restored, some at least of their relatives are certainly puzzled, and in many cases doubt their claim to consanguinity. Strangers, under the same circumstances, would be immediately attacked; these ants, on the contrary, were in every case—sometimes, however, after examination—amicably received by the majority of the colony, and it was often several hours before they came across one who did not recognise them.—*Nature*, February 20, 1879.

* Of about three of these Sir John did not feel sure.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SOME FACTS AND THOUGHTS ABOUT LIGHT-EMITTING ANIMALS.

By Professor P. MARTIN DUNCAN, M.B. Lond., F.R.S. &c.

[PLATE VI.]

AFTER the glare of daylight has passed into night, during the warmest months of the year, countless little points of light are often to be seen on the turf and amongst the brake and underwood in the open country of the South of England. The light is distinct enough, and when scattered far and near over a hillside, is always a matter of wonderment to the observer who witnesses the sight for the first time. When curiosity impels anyone to approach the little luminous points more closely, their "phosphorescent" gleam is evident enough, and the greenish white light glows. It increases and diminishes in its intensity, becomes bright and fades in a surrounding mistiness and again flashes out more brilliantly than ever. Hour after hour the green and white illumination persists, but if any one point be carefully watched, it will be observed to cease occasionally for a second or two, and often to move about. Towards the darkest hours the luminous points become more numerous and brilliant; but midnight witnesses the paling of the light which "fadeth at the crowing of the cock."

Searching amongst the grass for the cause of this remarkable light, the hand feels no increase of temperature on approaching the objects which relate to it, and successful seeking discovers a cold, softish insect.

At the same time of the year, when the summer's sun has warmed the surface of the sea, the darkest nights during calm weather off the coasts of our Islands are illuminated by fitful flashes of green, yellow, blue, and rarely red light, which, starting suddenly from one or two spots on the water, spread on all sides in coruscations, or in glowing ripples and increasing breadths, to cease as suddenly as they began. A boat glides into some quiet, dark harbour and sets the sea "aflame;" every dip of the oar produces an extending circlet of light, every drop of spray is luminous, and adds to the sparkling as it falls, and

the moving prow wells out little waves surging with tints of green and gold. Darkness, all the more intense by contrast, succeeds, to be again and again suddenly turned into transient light. In the offing, the sailors say the sea is "briny," and they watch the rippling radiance in their wake, and note the sudden gleams which, commencing at some disturbed spot of the surface, flash out on all sides. At anchor watch, whilst the night is as dark as pitch and the sea is hardly visible, the cable may often look white hot during the intervals of the faint illumination of the surface.

A bucket is lowered, and wood, ropes, hands and arms are alight with liquid heatless fire, and myriads of tiny globes may be seen occasionally in the water, intensely luminous. On going ashore up the wet sands, often enough every footstep is a focus of radiating glimmers, and remains luminous for a while.

These common sights, passed by by most people, are supremely interesting to the thoughtful, and they are the feeble Northern extension of similar phenomena, which are grand indeed in the sub-tropical and torrid regions of the globe, and which, even at some depth in the great oceans, may relieve the eternal darkness. But even on the verge of the sea, Nature's pyrotechny is superb, and Neptune is jealous of Nox, for in the short hour or two between the summer's daylight, spray, waves, and all they wash, are often intensely, long or momentarily, bright.

The dredge brings up, out of comparatively shallow water, Actinozoa, which, hitherto buried up to their tentacular ring, are light-emitting. A diver sees a luminous spot on the submerged limestone rock he is examining, and finds a boring shell smeared with luminosity. The weary sailor, tired with the monotony and the great heat of the tropical day, peering into the depths near the coral banks of North Australia and New Caledonia, sees long tracks of wandering light, and wonders at the graceful evolutions and fierce attacks of the sea-snakes, lit up as they are with a fiery path. Or, dreamily watching, he marvels at the radiant course of the predaceous fish as they rise to the surface and rush beneath, after their prey. Some whalers, when the ship is hove to and gently rolling in the dark nights of the Southern Ocean, see the mighty monsters shoot up above the gleaming surface amidst a fountain of lurid phosphorescent spray, and fall splashing again and again in ponderous play, as if they loved to show their strength amidst showers and waves of light. Sights such as these are not the invariable accompaniment of the darkness far away in Northern seas; for there the spreading phosphorescence of the surface often pales with the rising moon, or the display of the Aurora. But even then, mid-ocean becomes luminous as the tide carries the host of Medusæ along. Even when the moon is at its full, and the sea is bright with its lustre,

there is a world of light, deep down below the surface. Great domes of pale gold with long streamers, move slowly along in endless succession; small silvery discs swim, now enlarging and now contracting; and here and there a green or bluish gleam marks the course of a tiny but rapidly rising and sinking globe. Hour after hour the procession passes by; and the fishermen hauling in their nets from the midst, drag out liquid light, and the soft sea-jellies, crushed and torn piecemeal, shine in every clinging particle. The night grows dark, the wind rises and is cold, and the tide changes, so does the luminosity of the sea. The pale spectres below the surface sink deeper, and are lost to sight; but the increasing waves are tinged here and there with green and white; and often along a line, where the fresh water is mixing with the salt in the estuary, there is a brightness so intense that boats and shores are visible. But if such sights are to be seen on the surface, what must not be the phosphorescence of the depths? Every Sea-pen is glorious in its light; in fact, nearly every eight-armed Alcyonian is thus resplendent; and the social *Pyrosoma*, bulky and a free swimmer, glows like a bar of hot metal, with a white and green radiance.

Just as in some places in England, the points of light on the turf may be seen, simultaneously, with the luminosity of the surface of the sea close by, so in the tropics, active and flying specks of brightness compete on shore with the diffused splendour off the coast. All this light, so vast in its world-wide amount, is heatless. Crowd it all together, and a vast city might be illuminated without raising the thermometer probably many degrees, if at all; and all this vibration, this consequence of intensely rapid molecular motion, is the result of the energy of life.

The points of light on the turf of the South of England are produced by a beetle—the "glowworm," *Lampyris*; and the genus is world-wide in its distribution. The fire-flies of the tropics are principally Elater beetles, and others allied to them in classification; and there are Hemiptera as well as Myriopoda which add to the list. Our sea-surface illumination is due to myriads of *Noctiluca miliaris*, and the same and other species of the genus are world-wide. The minuter Crustacea, the Alcyonarians, Medusæ, Polyzoa, Ophiurans, Tunicata, Annelida, and Mollusca, add species to the luminous assemblage; and probably more than one hundred and fifty genera, most of which have numerous species which are prolific in individuals, are luminous under certain circumstances. It is possible that some fish noticed by Dr. Günther are phosphorescent in the deep sea.

The intensity and the colour of the light emitted, differ with the genus, species, locality, and season, and certain species have a definite and peculiar light. The English glowworm has

a misty-coloured light, which is usually greenish; that of Italy is brilliantly blue; whilst the Australian species emits a pulsating light. The fire-fly of the West Indies glows with a very white light; but it is doubtful if the *Fulgora*, so often seen in books as the Lantern fly, has a scarlet light, or any at all. The rapid coruscating flashes on the sea and on the sands, are now and then yellow or white, but rarely scarlet, or reddish, and are produced by crustaceans. Other insects in the tropics give out a deep blue and white light; and the Pacific Islands hundred-legs produce a brilliant emerald green. *Noctiluca* gives out a greenish and often bluish light, and the Medusoids vivid yellow, gold, green, blue and white tints. The Sea-pens give out white as well as coloured light; and that of the Echinoderms is green. The green and white tints are the commonest colours, yellow is rare, and so are the reds and blues, whilst purples are unusual. The Gorgonoids give out a beautiful lilac.

A very slight examination of the animals connected with these luminous phenomena, indicates that they are produced in different manners. For instance, *Noctiluca*, *Pholas*, and *Lampyris*, are readily anatomized, and the source of the luminosity is found to differ in each. Hence it is important to consider some typical cases which illustrate the varieties of light-production.

Consider, first of all, *Noctiluca miliaris* (Pl. VI. figs. 1–3), which is very common in the warm summer months all round the English coast and up the Humber and Bristol Channel. It is impossible to estimate the countless numbers of this minute, peach-shaped, flagellate infusorian in some parts of our seas. For instance, on the Essex coast some years since, I found every tumbler of sea-water taken out between the Gunfleet sands and the mainland, crowded with them; and most of the actively-moving, little gelatinous transparent things were larger than their standard of $\frac{1}{80}$th inch in diameter. They move by means of a filiform tentacle, of the length of the diameter of the body, and about $\frac{1}{1800}$th inch in its breadth, which is placed close to the opening of the so-called mouth. The tentacle is long and flat and has striations across it, but which appear to be beneath the delicate cuticle. A long, delicate, undulating fibril comes from the bottom of the oral cavity, and can be protruded and withdrawn, and close to it is a horny-looking, tooth-like body, $\frac{1}{7000}$th inch high. The opening into the interior, or mouth, is the extremity of a funnel, which ends within, in the minutely-granular substance forming the bulk of the body, and which, if it were perfectly transparent and uniform, no part being differentiated, might be called protoplasm. This granular sarcode has spaces in it containing water, or vacuoles, one often being large, but they do not contract and enlarge like those of many Protozoa. Radiating in meshes, which are coarse near the

mouth and very minute and fibrillar near the outside, is a denser sarcode, and there are granules on the fibrils. These fibrillar meshes are enveloped in a minutely-granular sarcode, and they reach to just under the surface of the animal, ending in a clear protoplasmic layer, which underlies the equally clear and transparent cuticle or cell-wall. Near the vacuolated part is a small nucleus, and it is evidently in relation with the fibrillar radiations; and there are occasionally nucleated cell-like bodies in the peripheral layer of protoplasm. As these are probably spores, it is not necessary to consider them. Now there is movement in the striated tentacle and in the long filamentous cilium, and there is amœboid streaming of granules on the radiating fibrils, but no change of general shape constantly occurs. The animal respires by its outer cell-wall, grows in size by additions to the finer granular parts, and the principal seat of this activity must be just beneath the cell-wall.

Now, on watching *Noctiluca* in captivity, one is struck by the very vivid light which it emits. It is a sudden flash, lasting but for a short time, and is repeated over and over again, some intermission being apparently inevitable and necessary. The light is greenish, and is produced not especially near the seat of tentacular and fibrillar movement, but just under the cell-wall. It arises from scores of minute, independent points, which scintillate and illuminate the rest: in fact, where respiration and assimilation are at their greatest, where the vital energy is in full action. Anything which increases this activity produces increase of the light, and the converse is true. Pure, highly aërated sea-water, changed over and over again, adds to its brilliancy and persistence. Oxygen forced into the water produces more light, and the stimulation of fresh (non-saline) water at first does the same, but sooner or later it is destructive to the animal. Physical stimulation evidently acts on the light, and produces it for a time, and a *constant illumination* precedes death, when light ceases. The light diminishes *in vacuo*, and under the influence of carbonic acid gas.

Quatrefages experimented upon *Noctiluca*, and added alcohol; and this produced a definite continuous luminous ring, and then a general peripheral illumination, which lasted for a while and until death. Finally, it is well known that nets which have been dragged out of a sea crowded with *Noctiluca*, retain light-emitting powers until the meshes become dry. The sun-light has nothing to do with the luminosity of *Noctiluca*.

The Spongidæ have not as yet been recorded as having luminous kinds, but the Hydrozoa teem with them; and moreover the gift, so common in the planoblasts, is found in some species in the stationary and vegetative animal. Probably nearly all Medusæ are luminous, and notably the larger *Aureliæ*

and *Zygodactylæ*, whose light is decided, although like a dim halo sometimes, but grandly golden at others, and especially when the creatures are broken by hauling in. Agassiz noticed that the blue tint of the seeming phosphorescence, was often due to a Medusa, *Dysmorphosa fulgurans*, which breeds others from its proboscis, and thus readily adds to its vast numbers. On the other hand, the stem or trophosome, out of which *Obelia* is developed, has a pulsating light running up it, whilst the free-swimming disc is said to be non-luminous. The globular jelly-fish with paddles, or the Ctenophora, so active in the sea, are brilliantly luminous, and it appears that many of the horny Sertularians give out light. The luminous part of the Medusæ is superficial when they are swimming and entire, and it appears to be restricted to the upper part of the umbrella, to the margin of the disc, and to the tentacles. But extreme irritation and tearing will develop light apparently everywhere, and the slippery semi-solid sarcode clings to everything, and is for a while luminous. It does not appear that the natural luminosity is greater underneath, where Schäfer has noticed radiating nerve-fibres, than on the top, where there is a delicate epithelium, whose flat cells contain minute points of fatty matter, and where no nerves have been found. The tentacles get luminous, and they are without any evidence of nerve, except perhaps where they start from the margin of the umbrella or disc. There is often much defined light at the so-called eye-spots at the edge of the disc, and it may be in relation to the epithelium there, related as this is to nerve. In the mass of the animal there is no highly differentiated protoplasm, but there is much of a low character, and it is all this that is so golden and white, when rupture has taken place. It is hard to believe that the nerves and fatty matters have anything to do with the luminous phenomena here, and certainly they have not in the trophosome of *Obelia*. Protoplasm, in a state of active nutrition, appears to be the seat of the movement which produces the light-wave.

It must be remarked that the great jelly-fish of our coasts and of other seas are not luminous during the whole of their summer life, for they may be seen crowding many estuaries in the hot months, as the twilight merges into night, and not a sparkle of light is visible amongst them.

Phosphorescence does not appear to have been noticed in the reef-building corals, nor in those solitary ones which can be kept in aquaria, but some of the Actinidæ, or sea-anemones, are brilliantly luminous. One notable example is the mud-loving, free, long-bodied *Iluanthos scoticus*, which leaves its rayed disc just above the surface of the ooze, shining like a star here and there, and retaining its light when brought up with the dredge. The extraordinary luminosity of vast numbers of

the Alcyonarian Pennatulidæ and Gorgonidæ compensates for the comparative absence of the phenomena in the other members of their group. Even in the cold North Sea, the Sea-pens, and their long-stalked, short-polyped allies, the *Virgulariæ*, add to the sea light, and the *Gorgoniæ* do the same. They are resplendent in the Mediterranean; and Moseley states that all the Alcyonarians dredged up by the *Challenger* from deep water were found to be brilliantly light-emitting, and that their phosphorescence agreed in its manner of exhibition with that observed in shallow-water forms. He examined the light emitted by three species of deep-sea Alcyonaria with the spectroscope, and found it to consist of the red, yellow, and green rays only.

Panceri notices the light of *Pennatula phosphorea*, which is an eight-tentacled Alcyonarian, with a stem with pinnate branches, carrying zooids or polypes. The long stem reaching below the branches consists of canal tubes, which are in communication with the polypes through the branches; and it is covered with sarcode that is comparatively rudimentary, and which is liable to become infiltrated with water, or to be hydropic, when brought up from the deep sea. The polypes, when fully expanded, are in rows on the upper surface of the branches, and each has eight pinnate tentacles, and at their base a slight swelling on the outside. From each of these eight swellings an opaque white cord passes down the outside of the visceral cavity of each polype to the sarcode of the branch.

These cords are canals in the sarcode, and when they are compressed, their contents may pass either into the hollow of each tentacle, or backwards into the tubular cavities of the branchlets and stem, and very little force suffices to burst them. When examined under the microscope, the contents are found to be cells and a fluid, and the opacity and white colour are produced by the cell contents, which consist of minute highly refracting globular particles, having, chemically and optically, all the properties of fatty matter. This substance is remarkable for its persistence without undergoing decomposition long after the death of the polype. In the substance of the cords there are cells which are stellate in shape, with prolongations, and resembling multipolar ganglion nerve cells; and others are simple enlargements along the course of a fibre. Besides these there are many albuminoid granules and some white particles of a mineral nature, but which does not consist of carbonate or phosphate of lime.

Now this Sea-pen is luminous universally, when seen under favourable circumstances in the open sea, and it has its hours of darkness. When caught to be experimented upon, the animal lights up in a very remarkable and definite manner. Should the long supporting axial stem be pinched, the polypes

nearest the stem on the lowest branchlets, become sparklingly luminous one after the other, and, when they are all illuminated, those of the next branchlets begin to shine, until in succession the whole are glowing. A slight interval of time, amounting to $\frac{4}{5}$ second, occurs between the stimulation and the appearance of the light, and the Sea-pen $6\frac{1}{10}$ inches long was illuminated in $2\frac{1}{5}$ seconds.

On pinching the top of a Sea-pen of this species, the lighting up commenced in the nearest polypes, and then those of the next lowest branchlets took up the effect, and the phenomena of the previous experiment, were simply reversed.

Again, on irritating one of the polypes at the end of a branchlet, its luminosity went to its neighbour, and then all followed one after the other; and if those at the beginning and ending of a branchlet were touched, the lighting up was towards those in and between them.

This successional illumination is very decided, and, when it is completed, the light is pretty constant. But it is evident that on irritating one of the polypes it "takes fire," as it were, at the edge of the tentacular apparatus, some luminosity remaining on the implement and in the intermediate water.

These remarks, the results of Panceri's interesting studies, may recall to mind the early experiment of Spallanzani, who, on compressing the stem of a *Pennatula*, obtained a light from the other extremity, and the fact that crushing the stem and a few branchlets, produces a *substance* which becomes diffused and lights up everything to which it adheres.

Careful observation has determined that when the pen is perfect, the light is emitted from the eight opaque cords of each polype, and that it can commence and continue without their rupture. On the other hand, rupture of a cord excites the luminosity of the whole, and the escaping fatty matter is luminous after its separation and after the death of the animal.

There is no sensible increase of temperature, and the tint of the monochromatic light is azure or greenish, but never red. In this beautiful instance of this remarkable vital luminousness there is evidently a photogenic structure and an elaborated organic material capable of producing light after removal from the animal. The sequence of illuminating is slow in the whole pen, and only at the rate of a yard in 20 seconds—a rate far less than that of the movement of nerve force. Yet the presence of the lowly-organised nervous element indicates that the regulating of the light may relate to it as its function. Clearly the phosphoresence of the Pennatulid is in advance of that of the simpler protoplasmic movement of the Protozoa and of the slime of the Actinoid. Sir Wyville Thomson notices the coming up, in a trawl let down to a depth of 2,125 fathoms of a magnificent "clustered

sea polype" (*Umbellularia grœnlandica*), consisting of "twelve gigantic Alcyonarian polypes, each with eight fringed arms, terminating in a close cluster on a calcareous stem ninety centimetres high." He states that when this splendid Pennatulid was taken from the trawl, the polypes and the membrane covering the hard axis of the stem were so brightly phosphorescent that Captain Maclear found it easy to determine the character of the light by the spectroscope. It gave a very restrictedly-continuous spectrum, sharply included between the lines *b* and D.* The same naturalist writes, after dredging in 828 fathoms off St. Vincent, that the trawl "seemed to have gone over a regular field of a delicate simple Gorgonoid, with a thin wire-like axis slightly twisted spirally, a small tuft of irregular rootlets at the base, and long exsert polypes. The stems, which were from 18 inches to 2 feet in length, were coiled in great hanks round the trawl beam and entangled in masses in the net, and as they showed a most vivid phosphorescence of a pale lilac colour, their immense numbers suggested a wonderful state of things beneath —animated corn-fields waving gently in the slow tidal current, and glowing with soft diffused light, scintillating and sparkling on the slightest touch, and now and again breaking into long avenues of vivid light indicating the paths of fishes or other wandering denizens of their enchanted region." †

Again, in the "Voyage of the Porcupine" ‡ the same fortunate naturalist noticed the Sea-pen, *Pavonia quadrangularis*, which entangled the dredge with its pink stems a metre long, fringed with hundreds of polypes, to be "resplendent with a pale lilac phosphorescence like the flame of cyanogen gas, almost constant, sometimes flashing out at one point more brightly, and then dying gradually into comparative dimness, but always sufficiently bright to make every portion of a stem caught in the tangles or sticking to the ropes distinctly visible."

Probably the grandest display of light-emitting is by the great cylindrical-looking *Pyrosoma*, one of the Tunicata (Pl. VI. fig. 5). This animal is really a compound one, and the common uniting tissue has the shape of a hollow cylinder rounded and closed at one end and cut short and open at the other. This is firm and transparent, like so much cartilage, and on its outside are arranged numerous whorls of separate zooids. Each zooid projecting is large near the supporting cylinder and smaller where free, and this end has the mouth opening, whilst the base is perforated by holes, which are continued through the cylinder. The water system thus opens into the hollow cylinder, and the water issuing

* "The Atlantic," vol. i. "The Voyage of the Challenger," p. 151. That is, in the green, near the less refrangible part.

† Thomson, *Op. cit.* p. 119.

‡ Thomson, "Cruise of the Porcupine," p. 149.

from it propels the whole in the opposite direction, at the same time that it revolves on its long axis. In the Mediterranean the Pyrosomes are from two to fourteen inches in length, and they may be three inches in diameter; they are seen in great companies, and when floating and revolving just below the surface, look like incandescent rods of iron. The light is said to be polychroic in the Pyrosome of the Atlantic, or of a vivid green; and it is azure in a gigantic species. It does not come, according to Panceri, from every spot on the body, but from two round spots, one on either side of each of the zooids, situated over the position of the ganglia of the nervous system, and there are loops like cords passing over the narrow end connecting them (figs. 1 and 2). They are placed between the two tunics of the integument, and are attached to the outer one. After a while the light becomes diffused over the whole surface. Panceri states that when the animal is not over-stimulated, the light is intermittent, and that it consists of sparks from the special cells in each zooid. The luminous bodies are photogenic structures, and produce an albuminoid substance, and also much that is soluble in ether. This matter may become diffused by handling, and retains its luminosity for some time. Panceri states that the light is increased by, and lasts long in fresh water. The largest kind of this wonderful light-emitting compound Tunicate is a grand sight in the night, as it gives out suddenly a vivid greenish light, large in its dimensions, and then it sinks to the depths. Moseley writes: "A giant Pyrosoma was caught by me in the deep-sea trawl. It was like a great sac, with its walls of jelly about an inch in thickness. It was four feet in length and ten inches in diameter. When a Pyrosoma is stimulated by having its surface touched, the phosphorescent light breaks out at first at the spot stimulated, and then spreads

Fig. 1. The open end of *Pyrosoma giganteum*, showing the zooids with their luminous spots.
Fig. 2. The outer end of a single zooid, with luminous spots, enlarged.]

over the surface of the colony as the stimulation is transmitted to the surrounding animals. I wrote my name with my finger on the great Pyrosome as it lay on deck in a tub at night, and my name came out in a few seconds in letters of fire."* Sir Wyville Thomson, noticing the "blaze of phosphorescence" off the Cape Verd Islands, states that the track of the ship was an avenue of intense brightness. "It was easy to read the smallest print sitting at the after-port in my cabin, and the bows shed on either side rapidly widening wedges of radiance, so vivid as to throw the sails and rigging into distinct lights and shadows. The first night or two after leaving San Iago the phosphorescence seemed to be chiefly due to a large Pyrosoma, of which we took many specimens in the tow-net, and which glowed in the water with a white light like that from molten iron."†

All luminous animals are not illuminators of the surface water or deep sea, for some shine where their gift is not appreciated by others. The burrowing shell-fish, *Pholas dactylus*, lives hidden up; but is nevertheless provided with photogenic structures and substances, and these are also nearly hidden in the enveloping tissues of the bivalve. The elongated cylindrical shells are well-known objects in most cabinets, and it is only necessary to state that the animal has a large foot, and that the combined siphons are large, cylindrical, and furnished with fringed orifices. Now, the photogenic structures are two parallel cords, containing opaque white matter running down the anterior siphon, and two small triangular spots at the entrance of it, and, lastly, an arched cord corresponding with the superior edge of the mantle, reaching to the middle near the valves. The cords and spots are convoluted lobes of the mucous membrane. The cords stand out in relief, and their white colour distinguishes them, and although they are only elevations of the subcuticular tissue, they contain special cells, or rather epithelium, which produces the phosphorescent matter. The whole surface of the *Pholas* is covered with ciliated epithelium, which dips down into all the parts of the animal; but the special epithelium differs from this. It is nucleated and crammed with granules, and the cells are very refractive. The cells are very fragile, and allow their contents, i.e. granular nuclei and refractive granules, to escape readily. These are soluble in ether and alcohol. Under ordinary circumstances this photogenic apparatus is hidden; but violence readily displaces the special cells, which burst, and their contents are carried all over the surface by the water, assisted by the general ciliation. The white substance, fat-like, retains its luminosity when spread out on paper for hours, but the light does not appear to be accom-

* Moseley, "Notes of a Naturalist on the Challenger."

† "Voyage of the Challenger," ii. p. 85.

panied by an evolution of heat. When it is placed in carbonic acid gas, the light pales and ceases. On the other hand, the photogenic substance, when barely luminous, is rendered so by physical contact. Agitation, and the addition of fresh or salt water, develop the light, and the same effect is produced by electricity and by heat. The light is monochromatic, and has a constant place in the spectrum as an azure band from E to F, that is to say, in the green, but in the more refrangible part.

The luminosity of one of the sea-slugs of the Mediterranean and Pacific is as remarkable as the creature producing it. Living a pelagic life, swimming freely with a fan-like vertical tail, this little transparent *Phyllirhoë bucephala* (Pl. VI. fig. 4) has no shell when in the adult stage, neither has it a foot, but its body is compressed and fish-shaped, and it has a round and truncated muzzle, behind which are two long flexible tentacles. It has no branchiæ, and respiration appears to go on through the general surface. Now to add to the beauty of this translucent creature, light-emission from many distinct round spots renders the tissues transparent and luminous. And when it is swimming vigorously, the whole surface shines with a diffused light. The sexes are combined in this delicate slug, which must be a nice morsel for many a fish, and which must find its phosphorescence a fatal gift. There does not appear, however, to be any special photogenic substance. The light comes from globular cells with an envelope terminating in the outer coat of a nerve. The cells are nucleated, and at first sight resemble Pacinian bodies without their internal structure. They nevertheless are terminations of nerves just under the cuticle. (Fig. 4*a*).

Some Ophiurans are brilliantly phosphorescent, and it may be said from our present knowledge, that those which live at considerable depths are more so than the shallow-water forms. Their luminosity has no reference to the temperature of the surface-water; and such a species as *Ophiacantha spinulosa*, which has a great bathymetrical range, is intensely brilliant when dredged out of very cold water. Sir Wyville Thomson has given a very interesting description of the phenomena in "The Cruise of the Porcupine." He writes: "Some of these hauls were taken late in the evening, and the tangles were spangled over with stars of the most brilliant uranian green; little stars, for the phosphorescent light was much more vivid in the younger and smaller individuals. The light was not constant nor continuous all over the star; but sometimes it struck out a line of fire all round the disc, flashing, or, one might rather say, glowing up to the centre: then that would fade, and a defined patch, a centimetre or so long, break out in the middle of an arm and travel slowly out to the point, or the whole five rays would light up at the ends and spread the fire inwards. Very young

Ophiacanthæ, only lately rid of their '*plutei*,' shone very brightly."

The position of the luminosity is removed from the nervous cords, and in decalcified specimens I have failed to trace nervous filaments on the top of the disc and in the substance, or near the upper arm-plates of the rays. But in a specimen from the Icy sea of North Smith's Sound, collected during Sir George Nares' expedition, and sent to me for description, I traced a filmy mucous covering here and there, which seemed to be an exaggeration of the excessively thin epiderm which evidently, in the young forms, covers the plates and the bases of the spines. The disc is covered with a crowd of minute spicular projections, each terminating in a bunch of small thorny knobs, or in three, four, or more rather sharp spicules. These delicate appendages are developed within the skin, as are also the granular elements which constitute the plates of the arms. It is possible that the luminous property resides in this delicate epiderm; and the probability is increased when it is noticed that the phenomenon is most decided in young individuals. It may be possible, however, that the Ophiuran has no photogenic structures, and that the light is the product of foreign animal substances which have become entangled by it as it moved over the mud of the sea floor on which it feeds.

Many years since, Quatrefages, in a very exhaustive memoir on the phosphorescence of marine animals,* attributed the light of the Ophiuran he examined to muscular contraction, and he found it arising between the plates of the arms. He did not see any luminous condition of the disc. But that this occurs is undoubted, and there are no muscular fibres there.

A considerable number of Crustacea are luminous under certain conditions, and the light-emission is sufficiently remarkable. In very transparent ten-footed kinds, and indeed in the small Entomostraca, as well as in many of the Sand-hopper group, a vivid short-lived light is emitted. Its colour is often redder than that of any other animals, and it is localized at first, for it starts from the junction of the legs with the body, and extends rapidly beneath the skin; and then it becomes diffused, the whole body glowing for a while. Some of the host of marine worms are luminous occasionally, and especially some of the genus *Nereis* and of the tube-making *Chætopterus*.

They emit a greenish light, and Quatrefages noticed that the phenomenon consists of a quick series of scintillations, which pass along several segments of the body, lasting but an instant. The flashes can be produced by irritating the worm, and they appear to accompany muscular contraction. Finally, as regards

* See the literature of the subject at the end of my article "Photogenic Structures"—"Micrographic Dictionary," third edition.

marine animal luminosity, the Cuttles and Squids are slightly light-emitting on their outer surface.

I am not aware of any fresh-water invertebrate which possesses the gift, and the statement that Infusoria are occasionally luminous does not appear to be founded on satisfactory evidence.

On land, certain Myriopoda give out a sparkling light, resulting from muscular contraction; and there is a remarkable slug found in Teneriffe, *Limax* or *Phosphorax noctilucus*, which has a luminous pore in the posterior border of the mantle. Many insects have little tiny spots on them which emit light, and it would appear that the localization of the minute phenomenon is in relation with wax glands. On the other hand, the great-headed Fulgora or lantern-fly is said by some naturalists to glow with red and white all about the forepart, and by other observers to do nothing of the kind.

The great display is produced by some species of two families of beetles, the *Lampyridæ* and *Elateridæ*, and the glowworm is one of the former. Belonging to the genus *Lampyris*, it is in classification, in the neighbourhood of the family *Telephoridæ*, and its close ally is the genus *Drilus*, in which great disparity between the sexes is not accompanied by luminous phenomena. *Lampyris* and *Drilus* lead the same kind of lives, and in the larval state are carnivorous, preying on snails, whose body they devour during life. As every work on Entomology has descriptions of species of *Lampyris*, it is only necessary to group the gifts of all, in the following remarks. The large yellow egg is even luminous on first leaving the body of the female. It is stuck on to moss, low grass, or even earth by a viscid fluid; and when it is hatched the long-narrow flat larva soon begins its cruel life, and has an apparatus for brushing off the slime of its victim. It attains its full size in warm Aprils, and some turn to the pupa condition in the summer; but usually the larva lives on, hybernates in the winter, and turns to the pupa in the spring. The larva has photogenic organs on the antepenultimate segment of the body (Pl. VI. fig. 9); they are on its under surface, one on each side of the middle line, and are like small sacs in shape. Overlapped more or less by the segment in front, they become visible when the insect extends its abdomen, and then they are noticed to be luminous. On the other hand, when the body is retracted they are hidden, and the light is not seen. Under all circumstances the light is excessively feeble.

When about to undergo the first metamorphosis, this larva becomes quiescent, and after skin-shedding, a pupa is presented—not a quiet one, however, for it has the power of moving the antennæ, head, and legs, and of twisting its body about and pushing itself along by the alternate contraction and expansion of the abdomen. The female pupa is without wings, but the

male has them, and the elytra, in a rudimentary condition. Both are slightly luminous. The last metamorphosis develops the perfect males and females, the last being apterous, the former being able to fly. Both, and not only the females, as has been popularly believed, are light-emitting, but the lady has greatly the advantage in brilliancy and in the extent of her photogenic apparatus. In her (fig. 7) they consist of six separate thin sacs of a white colour, each one occupying most of the width of the underside of a segment of the body. They are situate immediately beneath the skin of the ventral surface of the three segments which precede the last but one; and in the male they are on the penultimate and antepenultimate segments only (fig. 8). In the female the sacs on the fourth and fifth segments from the end are rectangular and large and the others are smaller. A thin expanse of the common soft integument covers them, and they are in contact with the last two nervous ganglia, many large air-tubes, and, in the female, with the sexual organs. They are exposed and hidden by the expansion and contraction of the abdomen, and their light is visible under the first condition; but when in full vigour, the luminous appearance may diminish, but not be quite lost under the second. This has something to do with the glowing. In all the grades of development the sacs are more worthy of the name of layers or laminæ, and they consist of a mass of large cells with nuclei, and refractive granules. These are aggregated without order, in the larva, and covered with an investing tissue, in which tracheæ (air-tubes) and minute nerves ramify, the tracheæ entering within and coming in contact with the cells joining on to their walls (fig. 10). In the female, the lamina is made up of a number of these cell-aggregates or organs, and there is a yellowish tinge in the part nearest the outer skin, and the back part is crowded with the refractive granules, and has a white and opaque tint. It is said, and one would like it more satisfactorily proved, that the refractive granules contain uric acid; and, on the other hand, it is by no means certain that the whole is not closely allied to that very recondite and unstable organic compound, wax.

Many entomologists are disposed to connect these highly fatty, light-emitting organs, so well provided with air-tubes and nerves, and so close to those organs where the most rapid structural changes progress in some periods of insect life, with the great mass of body and inter-muscle fat. This fat, however, diminishes with the advance of the sexual organs, and we know that in some insects a positive development of immature young takes place in it; but the luminous organ is present in the larva, and is most developed in the perfect state. Hence more knowledge is required before these views can receive universal acknowledgment.

The sacs continue to shine, for a while, after removal from the body, and the epithelium-looking cells retain their luminosity, when smeared over a moist surface for a time, but drying destroys the power. Oil and water do not affect the sacs; acids and alkalies arrest the light, and glycerine also, but the light returns on washing it off. The glow becomes extinct *in vacuo*, but returns on the admission of air.

Mr. Darwin writes, "All the fire-flies which I caught here (at Rio), belonged to the Lampyridæ (in which family the English glowworm is included), and the greater number of specimens were of *Lampyris occidentalis*. I found that this insect emitted the most brilliant flashes when irritated; in the intervals the abdominal rings were obscured. The flash was almost co-instantaneous in the two rings, but it was just perceptible first in the anterior one. The shining matter was fluid and very adhesive; little spots, where the skin has been torn, continued bright with a slight scintillation, whilst the uninjured parts were obscured. When the insect was decapitated the rings remained uninterruptedly bright, but not so brilliant as before. Local irritation with a needle always increased the vividness of the light. The rings in one instance retained their luminous property nearly twenty-four hours after the death of the insect. From these facts it would appear probable that the animal has only the power of concealing or extinguishing the light for short intervals, and that at other times the display is involuntary. On the muddy and wet gravel walks I found the larvæ of this *Lampyris* in great numbers. They resembled in general form the female of the English glowworm. These larvæ possessed but feeble luminous powers; and on the slightest touch they feigned death, and ceased to shine, nor did irritation excite any fresh display."

The Elater tribe furnish the commonest "fire-flies" of the tropics, and the light comes from a spot on either side of the front part of the body, where there is a yellow oval mass of cell-aggregates and tracheæ.

There is great scope for thought and speculation about all these facts, and it is evident that we do not yet know enough of the anatomy and physiology of the photogenic organs of many animals. But with our present knowledge it is possible to obtain some tolerably definite ideas on the subject of animal luminousness. Firstly, the spectroscope gives no satisfactory assistance. It tells us that the light is not produced by a gas, and still that there is something unusual about it, for the green part of the spectrum, in which it is found, glows as it were, in the least refrangible part, or may be said to be more intense near the red than in the other part of the green. That the term phosphorescence is of no scientific value is evident; it only relates to the

similarity of the glow of the *Lampyris*, and the light accompanying the oxidation of phosphorus, and there is not enough (if there be any) of the element in these tiny things to account for the special phenomena.

Fungi, decaying fish, and the flesh of lobsters are luminous under certain conditions, but the phenomena differ from those of the living animal, and are no more to be satisfactorily compared, than they are with the sharp emanation of light on the crystallization of tartar emetic, or with the results of the mixture of hydrochloric acid and arsenic during its crystallization.

It is evident that in some animals there is no special photogenic structure; that in others it is present as highly refractive cell contents; and in the Insecta there are aggregations of these cells into special organs, which are supplied with air-tubes, nerves, and blood. It is equally clear that whilst in the first and second groups, artificial irritation and the natural stimulus of the movement of the sea-water increase the light, and even induce it, there is still the power of intrinsic self-illumination. Quatrefages points out the extreme sharpness and brightness of the localized spots of light on *Noctiluca*, and insists that in a corresponding mass of them there is as much light given out as from the organ of *Lampyris*. There is, however, this difference between the light. It is extinguished in both *in vacuo*, but it returns only in the *Lampyris*. Two sets of phenomena are probably present, and in the simplest animal the physical cause of the light is probably different from that in the beetle. Certain it is, that all the agents which produce contraction of the protoplasm of *Noctiluca* determine the light, and if a persistent contraction is set up, the light is equally persistent, and death results. As the light comes from spots about the region where growth, the deposition of fresh protoplasm and its differentiation into minute granules are in full operation, and as moderately careful experiment has proved that there is no increase of temperature accompanying the light, the cause of it cannot be referred to "combustion," to oxidation, or to phosphorus, but to local and then general molecular movement of intense rapidity, which can produce light waves. In the instance of the *Pholas* large quantities of this luminous substance can be collected, but the temperature bears no relation to the light. If twenty or thirty female glowworms are put on the hand, which is rendered as visible as by the light of a candle, there is no appreciable temperature above that of the cold, clammy insect. The notion of oxidation of matter producing brilliant light without a measurable amount of heat is of no great value; and certainly if a female *Lampyris* glowing on damp grass so as to be luminous entirely underneath, and to have her light visible for many paces off, could evolve a corresponding or relational amount of heat, she would be fried.

During the daytime, if *Lampyris* be watched, whilst under the shade, she is not luminous as at night, and it is difficult by irritation to get her to shine. Again, there is manifest paling of the light after midnight, and the neighbourhood of the male causes both to flash out more. The influence of nerve is the most manifest in the Insecta, less so when the structure is rudimentary in the Alcyonaria, and it is absent in *Noctiluca*. But still, as the simplest nerve is protoplasm differentiated slightly and formed into masses and long lines; so even in *Noctiluca*, the light, situated as it is, at the very extremity of the thready protoplasm, which is ever streaming at its surface with granular matter, may be said to be in relation with localized potential, the energy of life. The phenomena of the so-called phosphori, or the luminosity of such substances as sulphide of barium, even when the emission of light is brief, is a consequence of molecular change and movement. Certain minerals obtain this movement after exposure to the sun, or to artificial but intense light, and in its production the energy of the light given has been transferred, and, as usual, more or less degraded. One can understand that if there is an energy of life, linked on to the unstable albuminoid, the basis of animal and vegetable organisms, and it can produce heat and electricity, it can, as the highest physical potential, produce molecular movement sufficient to develop light waves.

EXPLANATION OF PLATE VI.

Fig. 1. *Noctiluca miliaris*, magnified 100 diameters, showing the fibrillar structure; the flagellum (*f*): and the cilium at the oral aperture (*s*).

„ 2. *Noctiluca miliaris*, slightly magnified and luminous.

„ 3. *Noctiluca miliaris*, luminous portion highly magnified.

„ 4. *Phyllirhoë bucephala*, showing the luminous spots.

„ 5. *Pyrosoma giganteum*, reduced in size.

„ 6. *Lampyris noctiluca*, female, natural size.

„ 7. The same; the luminous organs enlarged.

„ 8. The male, its luminous organs magnified.

„ 9. The larva, its luminous organs magnified.

„ 10. Some light cells and their tracheæ magnified.

THE BIRTH, LIFE, AND DEATH OF A STORM.*

By ROBERT H. SCOTT, M.A., F.R.S., &c.

WHEN we are asked to give an account of the birth of a storm, we are reluctantly compelled to admit that our storms are, almost without exception, foundlings, and that, as the precise conditions to which they owe their origin are, for the most part, shrouded in uncertainty, warm discussions at times arise as to the parish from whence they have set out on their wanderings.

Dove said long ago that storms were due to the interference of the Polar current or the East wind with the Equatorial current or West wind. He gave the winds these names, because on his views the east winds really consisted of air flowing from the North or South Pole towards the equator, which was modified in the direction of its motion by its change of latitude; while west winds were really due to air endeavouring to make its way back to the Pole from the equator, whose course was in its turn modified by its moving from lower to higher latitudes. To the conflict of these two grand currents, east and west winds, Dove attributed all our storms; but he did not attempt to explain how the currents came into collision.

These views, however correct on their cosmical principles, have been superseded, of late years at least, as regards the explanation of our winds, by the modern views of the relation between the wind and the distribution of barometrical pressure; but, unfortunately, we still remain in comparative ignorance of the ultimate causes to which this distribution of pressure, or the rise and fall of the barometer, are due. To give some conception of the existing difference of opinion on these fundamental principles of our science, I may say that while some authorities maintain that the force of the wind in a hurricane is caused by the amount of barometrical disturbance which accompanies it, others hold

* Founded on a Lecture delivered by the Author at the London Institution, February 3, 1879.

that the fall of the barometer at the centre is itself, in great measure, due to the centrifugal force of the revolving mass of air.

Of the various theories which have been propounded to account for storms, which are generally more or less cyclonic in their character, I shall only mention four.

1. Some authorities, and amongst them our own countryman the Rev. Clement Ley, attribute the formation and subsequent progress of a storm to the condensation of moisture, but they apparently ignore the fact that many of our very heaviest rains do not give rise to cyclonic disturbances of serious character. For instance, when on April 10 and 11, 1878, 4·6 inches of rain fell at Haverstock Hill, we had no storm of wind at all. In partial confirmation of this view, Professor Mohn, of Christiania, points to the accidental condensation of moisture caused by the contact of a mass of damp air with the surface of an extensive snowfield as a possible cause of a storm. About the 61st parallel of latitude the glacier region of Justedal stretches for several miles along the coast of Norway, and this has occasionally been known to exert an influence in increasing the intensity of an existing cyclone, and even in some instances has appeared as the centre of a newly-formed depression.

These gentlemen, moreover, rely greatly on the fact that the rain area which accompanies every cyclonic system is roughly oval in shape, with its longer axis extending in the direction in which the system is advancing, and that by far the greatest amount of rain falls in front of the storm. They do not, however, explain the fact that very heavy rain frequently occurs on the northern side of a depression, where the wind is easterly, and that this circumstance does not indicate a northward motion of the system.

The most serious objection to this theory is, however, that first stated, that not only do the heaviest rains not come with the severest storms, but that frequently they are observed in times of nearly absolute calm.

2. The second theory to which I shall refer is the mechanical one, most strongly urged by Mr. Meldrum, of the Mauritius, whose investigations into the weather over the Indian Ocean have led him to the belief that every cyclone is generated in the intervening space between two oppositely flowing currents of air, of which the easterly moving stream, speaking in the most general terms, lies on the polar side of the westerly wind. Such a disposition of the currents would be that which would naturally arise were the cyclone once formed.

This view is called seriously in question by Messrs. Blanford and Eliot in their discussion of recent cyclones in the Bay of Bengal, which they have been able to study from very early

stages, and in which they fail to see evidence of the pre-existence of two, and only two, determinate currents.

Another serious objection to this theory is that it does not assign a *vera causa* sufficient to give the *first* impetus to the barometrical fall and the rotatory movement of the air.

3. A third theory of the origin of these storms is that which is strongly urged by M. Faye, in Paris, and is to the effect that, as interfering currents in rivers give rise to vortices which extend from the surface downwards into the water, so all our water-spouts, *trombes*, and even the largest tropical hurricanes must be all formed in the upper regions of the atmosphere, and extend downwards to the earth: the force which gives them their onward motion being supplied by the upper currents.

It is sufficient to say that this theory has not met with acceptance from any practical meteorologist, while it is directly controverted by recent investigation into the motion of cirrus clouds, which show beyond a doubt that the motion of the upper currents of air over a cyclone is outwards, and not inwards, as the descending theory would demand.

Moreover, some of our readers may have noticed in "Nature" of January 16, a notice, copied from the "Times," of the formation on the Lake of Geneva, on January 2, of a veritable small water-spout, 40 feet high and 10 yards in circumference, by the meeting of two winds, known locally as the *Föhn* and the *Bise*, on the surface of the lake. Here the waterspout was raised, and did not descend from the clouds.

4. The last theory we shall notice is that of the late Mr. Thomas Belt, who seeks for the origin of the disturbance on the ground, and, like M. Faye, assigns the same explanation to the smallest dust-whirl eddies and the largest storms which sweep over the earth.

This theory assumes as the first cause the heat of the sun. The heat-rays pass through the atmosphere without warming the upper strata, and so Mr. Belt supposed that over a sandy soil a mass of air close to the ground might rise in temperature much higher than the superincumbent layers of the atmosphere. The lower strata would therefore become lighter, and a condition of unstable equilibrium would arise. This, however, could not last for ever, and, sooner or later, the heated lower air would burst up, and the ascending column thus produced would be the nucleus of the nascent cyclone.

The difficulty in accepting this explanation is that we should like some ocular evidence of such a sequence of conditions. The supporters of the theory, however, point to accredited instances of the formation of whirlwinds over volcanoes like Santorin, and over extensive fires like those of Carolina cane-brakes.

In confirmation of these views of the effect of solar heat in producing a depression, I may cite an investigation by Dr. Hamberg, of Upsala, who has found that in July, 1872, after a prevalence of intensely warm weather in Southern Sweden, pressure gave way over the heated area; the isobaric lines following the trend of the coast; and a rotatory movement was thereby generated in the atmosphere above it, resulting in a perfectly formed cyclone which passed on over Northern Finland.

It would appear, therefore, that the production of a cyclonic disturbance may be attributable to more than one agency, as all the theories mentioned have some facts in their favour.

Leaving then this abstruse and imperfectly understood line of inquiry, let us proceed to a subject which yields us results of more immediate practical utility: the character and history of the storms when they have once started on their travels.

I shall commence by saying that a greater mistake cannot be made than to assert that *all* storms are distinctly connected with cyclonic disturbances.

The force of the wind depends on differences of atmospherical pressure over a given area, and the only reason why storms are generally associated with cyclones is that these systems afford us the most serious instances of disturbances of atmospheric equilibrium, and consequently of differences of pressure, which are met with on the globe.

At any place where an area of relatively high pressure comes into close proximity to an area of relatively low pressure, a gale will result, and so a storm may be due just as much to the rise of the barometer in one region as to its fall in an adjacent district.

For the same physical reason, however, that the eddies in a river extend downwards, and the water does not pile itself up in a peak, the normal disturbance of atmospherical equilibrium is the appearance of one of these vortices with pressure decreasing rapidly towards the centre. Wherever there is a rapid decrease there is a steep gradient, and consequently a strong wind.

Defining the term cyclone, in its very widest acceptation, as indicating a region of diminished pressure, round and in upon which the air is moving along paths which are more symmetrical all round the centre the more perfect is the circular form of the system, we must at once see that not every cyclone is accompanied by a storm. The fact is, that the direction and force of the wind are regulated by the difference of barometrical pressure over a given distance, and not in any way by the actual height of the barometer at the station at which the storm is felt, or by the distance of that station from the point where the barometrical reading for the time being is the lowest.

This explanation of wind motion is almost the only new

principle which has been recognized in our science during the present generation, and its practical importance is daily forcing itself more and more into public notice with the development of weather telegraphy. It is usually known under the name of Buys Ballot's Law, and is stated as follows:—"Stand with your back to the wind, and the barometer will be lower on your left hand than on your right."

The truth of this law is evident to anyone who looks at a weather chart, but the Dutch Professor, after whom it is named, though he justly claims the credit of having persistently advocated the acceptance of this relation of the wind to the distribution of pressure, was not by any means the first to discover it.

The final result of all the inquiries into the question is that on the mean of all winds the angle between their direction and the tangent to the isobar at the place is about 20°.

These principles of wind motion have a most important bearing on the theory of the motion of the air in hurricanes and typhoons. The old popular idea of these phenomena is that the air blew round and round the central calm in circles, so that any sailor caught in one of these storms could at once know that when he was hove-to, if he looked in the wind's eye the centre bore eight points to the right in the northern hemisphere, and to the left in the southern; or, what is the same thing, if he was scudding before the wind the centre would lie exactly on the starboard beam in the northern and on the port beam in the southern hemisphere.

Modern meteorologists, however, almost with one voice, declare for a spirally incurving movement as the most probable behaviour of the wind, as would be indicated by the angle which its direction makes with the isobars as just explained; but this view presents no novelty, for it was first stated about forty years ago, and Piddington, in his "Sailor's Hornbook" says that even Redfield, when propounding his "Law of Storms," stated:—

"I have never been able to conceive that the wind in violent storms moved only in circles. On the contrary a vortical movement, approaching to that which may be seen in all lesser vortices, aerial or aqueous, appears to be an essential element of their violent and long-continued action, of their increased energy towards the centre of axis, and of the accompanying rain. In conformity with this view, the storm figure on my chart of the storms of 1830 was directed to be engraved in spiral or involute lines, but this point was yielded for the convenience of the engraver."

We see, therefore, that when we trace back to its origin the belief that any storms are really circular, we find that it was "the convenience of an engraver," which decided the question.

It may be safely asserted that there does not exist for a single

instance of a West Indian hurricane or China Sea typhoon, a sufficiency of evidence to convince any unprejudiced investigator as to what was the true path of the air in the storm. To show this path beyond the possibility of doubt, we require a considerable number of simultaneous observations taken on different sides of the storm centre. These, however, were not forthcoming in the case of a single storm described by Redfield, Reid, or Piddington, so that the authority of the founders of the law of storms cannot be cited as decisive of the question.

This suggestion of spiral motion must of course modify the simple rule for a ship scudding, of looking in the wind's eye, and taking eight points on the starboard or port side for the storm centre, and indicates the probability that the true position of that spot will be at least two or three points ahead of the bearing given by that rule, so that the ship, if scudding, *may be* gradually approaching the most dangerous part of the storm.

The recent investigations of Mr. Meldrum which have been thoroughly confirmed by Captain Toynbee's examination of the Nova Scotia storm of August 24, 1873, lead to the suspicion, not to use a stronger word, that these cyclonic storms are not symmetrical at all, and that at some parts of the system the wind blows directly towards the centre, so that for a ship in such a situation, and scudding before the wind, the centre would lie right ahead.

This is a subject which requires most careful study, in order to see whether or not the time-honoured rules for handling ships in rotating storms require modification.

I shall now leave the subject of the air motion, and proceed to describe the phenomena of a cyclonic disturbance when it passes over us. In the first place, very few of them, in these latitudes, exhibit much approach to a circular shape, as regards the course of the inner isobars, and we may say that none of them develop equal violence in all segments. The reason of these differences in the force of the wind is to be found in the distribution of pressure in the vicinity of the storm area, for if on any side of that area there exists a region of high barometer readings, on that side steep gradients will be produced, and of course proportionably great violence of the wind. The actual weather phenomena of a typical cyclonic disturbance, if plotted on a diagram, show very clearly how cloud and rain prevail over the whole front of the system, and how in the rear, where the wind is north-westerly, the sky clears up. There is one fact worth remembering about these storms, and that is, that just before the sky clears a very smart squall of rain frequently comes on; so that we get this practical hint, if during a westerly gale we find the rain becoming exceptionally heavy we may look for the weather speedily to clear up.

Such a diagram also shows us that it is quite a mistake to consider all east winds as dry ones, for in a cyclonic system the cloud area extends on the northern side, where the wind is easterly, nearly as much as on the southern, where the wind is from the westward. In fact, many of our wettest days occur with easterly winds, when one of these depressions passes to the south of the station where we may be.

I shall now proceed to give a slight sketch of what we have learnt of the movement of storms. This, as far as we can see, is regulated by the position of the areas of high pressure, or, as they are called, the anticyclones. This is a term introduced about fifteen years ago by Mr. Francis Galton, to indicate an area of excess of pressure out from which the air is slowly whirling with a motion opposite to that which it has in cyclones. If we find an anticyclonic area existing over any region, we know that the cyclonic disturbances will skirt round it and develop their strongest wind on the side which lies closest to the district of high pressure.

Thus if the anticyclone lies over France, the cyclonic disturbances will move from west to east over the British Isles. If the area of high pressure lies over England, the depressions will sweep outside the Scotch coast, and reach Norway north of the 60th parallel. If the anticyclone lies to the westward, and the pressure is higher in Ireland than in Great Britain, there is danger of northerly gales on the east coast of England, from cyclonic disturbances travelling southwards over the North Sea.

In every case the cyclone moves with the prevailing wind along its track.

Unfortunately we know very little about the rate at which these storms advance, some of them moving at the extraordinary speed of 50 or 60 miles an hour, as for instance, that of March 12, 1877; while others, like the West India hurricanes, do not attain one-fourth of that rapidity of translation. It is remarkable that the rate of progress bears no relation to the intensity of the storm, the slow moving tropical hurricanes being infinitely more violent than many of our rapidly moving disturbances: although the storm already mentioned in March, 1877, was severe enough, at least in the north of France, to satisfy any requirements.

As regards the distance which storms have been known to travel, I may cite a very long-lived storm, which lasted nearly a fortnight in August, 1873, and which was traced along its course by my friend, Captain Toynbee, by means of the logs of 260 ships which were in the Atlantic during its continuance. Its history will be found in the last published work of the Meteorological Office, "The Weather over the Atlantic Ocean during August, 1873." This particular storm wrought immense

damage on the coast of Nova Scotia. It did not, however, travel as far as Europe, having disappeared in the neighbourhood of Newfoundland. In fact, very few storms have really been proved to maintain their individuality during their transit. Professor Loomis, an American meteorologist, who has devoted much attention during the last 20 years to the connection between European and American weather, has very recently published a paper on the results of discussion of two years' daily synoptic charts of the Atlantic. During that interval 36 areas of depression were traceable across the Atlantic, that is, at the rate of 18 a year. Testing these by wind reports from England alone, he finds that the chance that a storm centre coming from the United States will strike England is only 1 in 9; of its causing a gale anywhere near the English coast it is 1 in 6; while the chance of its causing a strong breeze is an even one.

This brings us to a subject which has attracted an immense amount of public attention in this country and in France: the practical value of the warnings which have been sent over by the "New York Herald" during the last two years. By "practical value" I mean the value to our fishermen and coasting sailors, for whose benefit, more than for that of seagoing men in large vessels, the whole system of storm-warnings has been called into being. It is evident that a warning which is locally unfulfilled may mean a loss of some hundreds of pounds to a fishing fleet; and although the storm to which it referred may have reached some parts of the coasts of Europe, yet if it did not visit the precise district where the fishing was being prosecuted at the time, the fishermen in that district were not benefited by the warning. On the contrary, they were the worse for having received it, on the old principle that "Wolf! Wolf!" should not be cried too often.

Of course, every word that I here say as to the usefulness of warnings is just as true with reference to warnings issued by our own office in London as to those of the "New York Herald," but these latter are often very general in their scope. They speak occasionally of a storm reaching the British Isles and France, and affecting Norway. This haul of the net embraces 25° of latitude, from 45° to 70°, and it is an unheard-of thing that a gale should prevail simultaneously over such an immense tract of coast, so that on each occasion the seamen in many harbours cannot derive immediate benefit from the publication of so vague an announcement.

It is one thing for a scientific man to say that he can recognise the presence of the predicted cyclone on our coast—Professor Loomis admits that the chances are even that he should do so—but it is a totally different matter to prove that a gale which begins two days before, or two days after the time of a

predicted storm, is really the very disturbance which left the American coasts.

The experience of those who have studied cyclone tracks in Northern Europe shows that in winter, on an average, a cyclonic disturbance visits some parts of those regions every fourth day, so that if a warning were announced once a week regularly, there would be nearly a certainty of some sort of a fulfilment.

The results of a most careful comparison of these warnings with the weather experienced by us during the years 1877–78, are given by the following percentage figures:—

	1877		1878	
Absolute success	17·5	42·5	27·0	45·0
Partial success	25·0		18·0	
Partial failure	15·0	57·5	10·0	55·0
Absolute failure	42·5		45·0	

In order to obtain so favourable a result as 45 per cent. of general success, great allowances have been made. Thus it has been considered an absolute success if a gale was felt on *any* part of the coast, whereas the prediction was for *all* parts; and when three separate storms were predicted in one telegram, none of which arrived, only one failure has been counted.

It is, therefore, pretty clear that these warnings have not, as yet, proved themselves to be of much practical utility to our coasting trade and our fishermen. The question is a most interesting one, and although a satisfactory solution of it has not been attained, we need not despair; but we should attack it from the scientific side, and discuss the results in a calm, dispassionate spirit, and through some other medium than that of letters to newspapers.

Let us now leave these American warnings, and see what we know about the movement of storms over Western Europe, which is the problem which most immediately concerns us here. The illustration has often been used that meteorologists, in issuing storm-warnings, and having to estimate the direction and rate of motion of every storm the instant it shows itself in their neighbourhood, are in the position of astronomers expected to assign the path of a comet from the first glimpse they get of it through a break in a cloud—a problem which all will allow to be impossible of solution. Accordingly, great interest attaches to the attempts made from time to time to lay down principles for forecasting the motion of the disturbance.

I have already stated that, as a general rule, the cyclones move round the anticyclones; but this principle requires for its application to storm-warning purposes, access to charts embracing a very considerable extent of the earth's surface. These are very difficult for Englishmen to obtain, as our own daily charts are very limited in area, and frequently do not exhibit even the whole extent of a single cyclonic depression, much less its relation to the distribution of pressure all about it. For

those, however, who can consult such charts it is possible, so to speak, to take their stand at a higher point of view and survey the conditions prevailing, say over Europe, on any given day.

If the amount of change in the pressure or of rise and fall of the barometer during the preceding night be plotted every morning on such a chart, it is found that the path of the system for the day does not lie directly towards the region where the greatest fall has occurred during the night, but is regulated to a certain extent by the direction of the line drawn from the point of greatest fall to that of greatest rise.

Another theory of storm motion, strongly held by those who attribute all our storms to condensation of vapour, is that the track of the depression is always directed towards the region where the air is dampest. This principle, like that just noticed, can hardly be turned to account in this country for our own practical benefit, inasmuch as the whole of these islands appear to be almost equally damp, owing to the proximity of most of our telegraphic reporting stations to the sea.

Other suggestions have been made in various quarters, with the view of throwing light on this very important subject; but we cannot say that the results have met with general acceptance, and the matter urgently demands further study.

I must now come to the final portion of my theme—the Death of a Storm; and on this subject, unfortunately, I have very little to say. As we have not been able to produce evidence of the birth of a storm, so have we never been lucky enough to find any one who was in at the death. In fact, some French meteorologists have hazarded the statement that storms can travel all round the world until at last they travel off it.

Storms have been traced from the Pacific coast of North America across the Atlantic; but these instances are necessarily rare, and, as far as European experience goes, no storm arriving from the Atlantic ever travels far into Russia. This fact is, of course, very much in favour of the condensation theory of storm generation, which has already been noticed. The advocates of this view plead very plausibly that, as the moisture in the air is the food of the storm, so, where that moisture is deficient, the storm dies of starvation.

We may, however, point out to them that eddies in a river and dust whirls at street corners waste and wane without any assistance from vapour condensation.

In conclusion, though it is a humiliating confession for us to make, meteorologists are as yet entirely in the dark as to the reasons why one depression fills up while another becomes deeper. As I have already stated, no meteorologist is able to give a straightforward answer to the simple question, What causes the barometer to rise or fall?

ON THE EXTINCT ANIMALS OF THE COLONIES OF GREAT BRITAIN.*

BY PROF. RICHARD OWEN, C.B., F.R.S., &c.

AT the conclusion of my student's career at Paris, in the time of Baron Cuvier, my first application of that great teacher's "Laws of Reconstruction of Extinct Animals from their Fossil Remains" was to those of the British Isles,† of which study the results, as relating to the mammals,‡ birds, and reptiles, § have been published.

I next turned my attention to the fossil evidences of these classes of animals in the Colonies of the Empire; and I propose to submit to the Royal Colonial Institute, on the present occasion, the chief results in relation to the Cape of Good Hope, Australia, and New Zealand.

CAPE OF GOOD HOPE.

My present notice of the evidences of extinct animals of the Cape of Good Hope will be limited to those of the Reptilian class, to which the South African crocodiles, tortoises, lizards, and toads are now the animals nearest akin. Of fossil remains of serpents I have received none; nor are any of the fossil reptiles which have reached me from the Cape allied in genera, families, or even orders, to those now existing in the world. All the Cape subjects of my attempts at restoration are from what are commonly termed the "Karoo beds," covering an area of over 200,000 square miles, extending between latitudes 35° and 33° 30′ S. and longitudes 20° and 28° E. They overlie deposits

* A paper read before the Royal Colonial Institute, May 6, 1879, and printed here by permission of the Author.

† "Reports of the British Association," vols. for 1839, 1841, 1842, 1843.

‡ "History of British Fossil Mammals and Birds," 8vo. 1846. (Van Voorst.)

§ "History of British Fossil Reptiles," 4to. Parts I.-VI. 1849-55. (Published by the Author.)

of Devonian and Carboniferous age, and include those answering to European Permian and Trias, and consequently are of older date than the Oolites and Liassic cliffs in England from which have been derived, among other strange reptilian forms, the numerous kinds of ichthyosaurs and plesiosaurs.

The Cape fossils are imbedded and petrified in shales and rocks of quartzose sandstone, the strata of which slightly incline in their southern verge from horizontality. They seem to have been deposited from lacustrine or estuarine waters during a lapse of time which may be conceived from the mountain ranges into which they are now elevated. The following vertical thickness of the fossiliferous strata has been ascertained: at the Stormberg Beds, 1,800 feet; at the Beaufort Beds, 1,700 feet; at the Koonap Beds, 1,500 feet; at the Upper Ecca Beds, 1,200 feet. These stratified beds, or basins, of ancient waters, have been, in the course of their upheaval, traversed by trap dykes, and the consolidating and elevating forces to which the shales have been subjected have converted them into the hardest and most intractable rocks that my chisel ever operated on: they "strike fire" at every blow. The difficulty of extricating the imbedded teeth and bones of the strange creatures that haunted the banks and shallows of the ancient lakes or estuaries is enhanced by the near correspondence in colour of the petrified parts to the dark, often black, rock in which they are enclosed.

In the year 1838 Mr. Andrew Geddes Bain, employed in the construction of a military road north of Fort Beaufort, observed in parts of the rock he was blasting portions like teeth and fragments of bone; these he transmitted to the Geological Society of London, and they were referred by the Council to me to report on. The result was so novel that Mr. Bain was encouraged to persevere in the collection and transmission of such evidences, and received for that purpose grants of money from the Geological Society and from the Trustees of the British Museum. I kept up communication with Mr. A. G. Bain until his demise, and have continued the same with his son, Mr. Thomas Bain, the present Surveyor of Roads to the Cape Colony.

The rich series of fossil evidences from these gentlemen have been supplemented by specimens transmitted by successive Governors (Sir George Grey, K.C.B., and Sir Henry Barkly, K.C.B.), by H.R.H. the Duke of Edinburgh, by Dr. Guybon Atherstone, of Graham's Town, by Dr. Rubidge, by J. M. Orpen, Esq., Government Surveyor of the Cape, and by several friendly colonists.

Besides separate Reports and Memoirs in the "Transactions" of the Royal and Geological Societies, the fossils so received

have afforded subjects filling seventy plates of a quarto work of 100 pages of text. *

I think the most extraordinary, as it was the first to be restored, of the old Cape reptiles was a creature attaining the size of a walrus, and which, like that amphibious mammal, had a pair of long, pointed tusks descending from the upper jaw. But it had no other teeth, and it combined the two-tusked character with a lower jaw, edentulous, like that of a tortoise, and a skull exemplifying crocodilian and lacertian structures. Many species of this type, varying in size, came successively to hand, and exemplified the genus called *Dicynodon*. Other two-tusked reptiles required a distinct generic section, called *Ptychognathus*. A third extensive series carried the tortoise likeness further by the absence of tusks, but with the same composite cranial structure as in the Bidentals; and, in short, a series of Reptilia was brought to light which necessitated the formation of a new order in the class, to which was assigned the denomination of Anomodontia.

Now, although no true coal has been met with in the Karoo strata, although present in the older Devonian series, at the Cape, called the Kowie Coal Beds, yet remains of a rich series of vegetation on the land traversed or occasionally visited by the Karoo reptiles have been detected. I was not surprised, therefore, to receive evidences of huge herbivorous dragons, akin, although remotely, to our own liassic scelidosaurs and the Wealden iguanodons.

The jaws of the *Tapinocephali*, of the *Pareiosauri*, and of the *Anthodons* were armed with close-set series of equal-sized teeth, having crowns adapted to crush and pound vegetable substances, and were associated with modifications of the skull for horizontal grinding movements of the jaws. A significant fact was elicited by scrutiny, and sections of parts of the backbone of these Dinosauria. The bodies of the vertebræ retained more of the fœtal structure than has been met with in any post-triassic herbivorous reptile. Those of *Anthodon*, for example, were bi-concave, as in fishes; and those of *Pareiosaurus* and *Tapinocephalus* carried the primitive embryonal character a degree further. The apices of the hollow terminal cones, which nearly meet in the centre in *Anthodon*, quite meet in the other genera, exemplifying the persistence in those huge dragons of a continuous, beaded notochord. Hence the necessity of placing them in a distinct section of Dinosauria, called "Tretospondylia," and it may be, as our restorations become completed, that erpetologists will regard them as the types of an order distinct from the later forms of Dinosauria.

* "Description of the Fossil Reptilia of South Africa," 4to. 2 vols. 1876. By Professor Owen. Published by the Trustees of the British Museum.

In the Trias of Europe had been found the jaws and portions of skull of a fossil creature provided with large flattened crushing teeth, like a pavement covering the palate above, and the correspondingly broad tracts of the under-jaw. These fossils were referred by Agassiz and H. von Meyer to a supposed extinct fish *Placodus*. The first specimen of this rare genus that came to my hands, from Germany, showed, however, characters which led me to think it was a reptile, not a fish. It was with much pleasure, therefore, that I found among the Cape fossils an unequivocal and larger extinct reptile, provided with similar crushing teeth, and with these only; forming, likewise, a pavement upon the palate opposed to similar teeth on a broad alveolar tract of the lower jaw. Since describing and figuring this fossil, under the name *Endothiodon*, I have lately received a second species of the same genus, also from the Karoo beds. It is, of course, significant to note that the only analogous form of reptile from localities elsewhere than at the Cape had left its remains in deposits of Triassic age. At the present day, the only known aquatic vertebrates adapted by their teeth to crack and crush shell-fish belong to the class of Fishes: such, for example, are the Wolf-fish (*Anarrhichas*) and the Port Jackson Shark (*Cestracion*).

An extensive series of Reptilia has been brought to light from the Cape fossiliferous beds above specified, which were of a more strictly and decidedly carnivorous nature than the Dicynodonts, combining upper tusks of a more piercing and trenchant character opposed to a pair of similar tusks below, crossing in front of the upper pair when the mouth was shut. These killing and holding teeth, like the canines, or laniary teeth, of the lion and dog, were preceded by incisor teeth of a similarly pointed shape, and followed by molar teeth, of the character of those called carnassial or sectorial in Mammalian feræ. This type of dentition, in which the "incisors," "canines," and "molars" can be specified on characters of size, shape, and relative position, had hitherto been unknown, save in the Mammalian class; but it is combined in these extinct Cape creatures with a true reptilian or cold-blooded cranial and vertebral structure. With this guiding evidence of the reptilian class of our present series of fossils, I further found, associated with such dentition, that the teeth were retained, as in Mammals, sufficiently long for the fangs to dwindle and become consolidated at the implanted end; that the humerus, with ridges and processes adapted to as free evolutions of the fore-paw as in the lion, also showed a canal for the passage and defence of a brachial artery and nerve, not present in any existing kind of Reptile, but characterizing the humerus in many, especially feline, carnivorous Mammalia. Furthermore, that the paws were supported by joints or pha-

langes in the same numbers, or according to the same formula, as the Mammalian paw.

Detecting many and various modifications of this carnivorous reptilian type, I felt constrained to group them into a distinct order, called Theriodontia. This order was exemplified in South Africa by a species and genus (*Titanosuchus ferox*) surpassing the lion in size; by others as large as a leopard (*Lycosaurus pardalis*); and by others, again, as small as a cat or foumart (*Galesaurus* and *Procolophon*). I may also note a fact of some significance, that the incisive formula in the Theriodonts is not that of the higher or placental Mammals, but of the lower, more reptilelike, marsupial ones. Thus, *Cynodraco* has $i\,\frac{5-5}{4-4}$, like the opossums (*Didelphis*); *Lycosaurus* has $i\,\frac{4-4}{3-3}$, like *Thylacinus* and *Sarcophilus* (the native hyæna and devil of the Tasmanian colonists); while the placental Carnivora never show more than $i\,\frac{3-3}{3-3}$.

In the existing Reptilia the characters above specified are wanting. They would have been unknown and unsuspected as reptilian ones, save for such researches as are here summarized. If the gap in the series of animals continued from the Triassic to the present period had not been filled up otherwise than by reptiles, the living remnant of that class would have testified to total loss of such gains of organization as had enriched the predecessors of modern tortoises, lizards, and crocodiles.

We now know, through discovery and study of fossil remains, that not one of the gains which benefited our extinct reptiles has been lost, but has been handed on, and advanced through a higher type of vertebrates, of which mammalian type we trace the dawn back to the period when reptiles were at their best, grandest in bulk, most numerous in individuals, most varied in species, best endowed with kinds and powers of locomotion, and with instruments for obtaining and dealing with both animal and vegetable food.

Then obtrudes the question, and will not be parried, Has the transference of structures from the Reptilian to the Mammalian type been a seeming one, delusive, due to accidental coincidences in animal species independently created? Or, was the transference real, consequent on the incoming of modified species by way of descent, and through the operation of a secondary law? Certain it is that the lost reptilian structures defined in this paper are now manifested at the Cape of Good Hope by quadrupeds with a higher condition of cerebral, circulatory, respiratory, and tegumentary systems. But into these higher generaliza-

tions of biological science it is beside my present purpose to enter.

I therefore next proceed to notice the Extinct Animals of the Colony of

New Zealand.

When Cook re-discovered,* or, for us, virtually discovered New Zealand, in 1769, he was accompanied by Solander, a pupil of Linnæus, and by Joseph Banks, an ardent collector of facts and objects of Natural History. They made every effort, and tried every means of inquiry of the friendly natives, in pursuance of their quest. A dog, resembling that which they had seen in the Polynesian islands, and probably introduced into New Zealand by the Maories, was noticed, and a species of rat was obtained, which was fostered for food by the natives. Bats had flown thither, but no wild land-mammals were seen or heard of. Although Captain Cook was enjoined by the "Admiralty Instructions" to bring home "any extraneous fossils" he might meet with, none such were obtained in New Zealand; nor could any information be extracted as to any beast or bird notable for its large size that then existed or had existed in the island. In the Maori "Vocabulary" appended to the "Voyage," neither the word "Moa" nor "Movie" occurs. The natives gave no sign that they knew anything of gigantic birds which had served their ancestors for food.

Subsequent expeditions, having natural history more directly in view, sent out by the French Government, were equally unsuccessful. The accomplished zoologist Lesson, accompanied the *Voyage de la Coquille* in 1820. MM. Quoy and Gaimard were attached to the *Astrolabe* (1827). The *Zoologie* of both voyages was brought out in detail and with rich illustrations by the French Government, but no clue to the singular extinct avifauna of New Zealand was obtained. Confirmation was recorded of the small wingless bird, the Kivi, of which Captain Barclay of the ship *Providence*, had brought to England a skin, in the year 1812; but no idea was suggested of the gigantic race of which that bird has proved to be the sole survivor.

One afternoon in the year 1838, as I was preparing for a lecture, an individual was announced, who unwrapped a bone which he stated he had obtained in New Zealand from a native, who told him it was the bone of a great eagle, and for this specimen the man asked the sum of ten guineas. I assured him he had been misinformed, that no bird of flight had a bone

* Abel Tasman reached the west coast of New Zealand in December 1642. He made no observations on the animals or products of the islands, and departed, after the slaughter by the natives of four of his crew.

of that structure; that it was a "marrow-bone," in shape and size like those brought to table wrapped in a napkin.

To further questions as to its locality, the vendor replied by showing, among other evidences, a jade-stone weapon, which I knew to be peculiar to the New Zealanders; and he still attached so much value to the unpromising fragment, that I consented to try to make out the bone if he would leave it, and call the next day.

After "lecture," I took the bone to the skeleton of the ox, expecting to verify my first surmise; but with much resemblance to the shaft of the thigh-bone, there were precluding differences; from the arm-bone (*humerus*) of the ox, which also affords the tavern delicacy, the discrepancy of shape was more marked. Still, led by the thickness of the wall of the marrow-cavity, I proceeded to compare the bone with similar sized portions of the skeletons of the various large quadrupeds which might have been introduced and have left remains in New Zealand.

In the course of these comparisons I noted certain superficial impressions which recalled to mind similar ones which I had observed on the surface of the bones of some large birds. Thereupon, I proceeded to the skeleton of the ostrich. The "bone" tallied in point of size with the shaft of the thigh-bone in that bird, but was different in shape. In the latter character it was more like the thigh-bone of the cassowary; but it differed in a more important particular from that bone in the ostrich, cassowary, emu, rhea, and eagle, inasmuch as in those birds the femur is "pneumatic," or contains air, whereas the huge bird's bone in question had been filled with marrow, like the thigh-bone of a beast.

I was almost staggered by the conclusion in which I was landed. Could a bird as big as an ostrich, and of a more massive build, have ever found subsistence in so small an island as New Zealand? All analogy seemed against it. The ostrich has the whole continent of Africa for its home, the rhea roams over South America, the emu over Australia, the cassowary over New Guinea!

These considerations, indeed, told more strongly with the then master-ornithologists, my seniors, Vigors and Yarrell, and to whose judgment I looked with due deference. Yet their scepticism was more natural from their not being practically familiar with the force of palæontological evidence. And, as I urged, this huge bird, if I could be credited, was new to Science, and so might as well have come from New Zealand as from anywhere else. In short, the "Paper" was admitted into the "Transactions" of the Zoological Society, with one plate, giving four views of "the bone" in question.

On the publication of the volume in 1839, one hundred extra copies of the paper were struck off, and these I distributed in every quarter of the islands of New Zealand where attention to such evidences was likely to be attracted.

At that date their acquisition to Great Britain was mainly promoted by the "New Zealand Company," whose agent, Captain William Wakefield, was zealously carrying out the principles of colonisation advocated by his brother, Edward Gibbon Wakefield. Through J. R. Gowen, Esq., a director of the company, the distribution of my paper was recommended and efficiently carried out by Captain Wakefield.

The missionary promptly worked in the track of the colonist. Imperial recognition became inevitable. First a Governor, then a Bishop, Dr. Selwyn; afterwards a Chief Justice, my friend Sir William Martin, went out. Upon each and all I pressed the claims of the possible big bird of New Zealand to attention according to leisure and opportunity. The years 1840 and 1841 passed, and I began to doubt, but misgiving went no further than as to locality; of the bird itself I may say I was "cock-sure." Toward the close of 1842 came the welcome letter of the Rev. William Cotton, M.A., companion of the Bishop, announcing the discovery of big bones in the North Island; and this was followed by the arrival of a boxful transmitted by a fellow-missionary, now the Right Rev. Bishop Williams, to Dr. Buckland, by whom these specimens were generously confided to me for description. They included a nearly perfect specimen of the bone of which I had received the shaft, and with it the other bones of the hind limb of the same bird. These afforded adequate grounds for defining a genus *Dinornis*, and a species *struthioïdes*. But what I was not prepared to see, and saw with amazement, were similar evidences of a larger species of the same genus, a *Dinornis ingens*, and other remains of a still larger kind, *Dinornis giganteus*. But might not these be parts of individuals of the one and the same gigantic bird at different stages of growth? The answer to this question is given by the well-marked characters of immaturity which the bones of the bird's leg display, and especially the third or metatarsal bone, which is a compound one, and does not acquire the consolidation or coalescence of its three or more constituent elements until maturity is reached. Moreover, with the above evidences of birds of the same genus, surpassing in size any previously known, were others of smaller size, also of full-grown birds. They indicated the former existence in New Zealand of a *Dinornis casuarinus*, a *Dinornis dromioïdes*, a *Dinornis otidiformis*, so called as agreeing in size respectively with the cassowary, the emu, and the bustard. Of the latter I subsequently received remains justifying its title to a distinct genus,

Apteryx. All the others belonged to the genus *Dinornis.* Correspondence was kept up with every contributor in New Zealand of specimens and of information bearing upon this new chapter in Ornithology. Year by year accessions of fossils reached me; all were of the class of Birds.

No evidence of an extinct mammal or of an extinct reptile has hitherto been obtained from the comparatively recent formation yielding the avian remains. The progress of restoration was in two directions, one in perfecting a knowledge of the entire skeleton of an individual, the other of the specific and generic modifications of these extinct wingless birds. The law of correlation, justifying the affirmation from the first fragment that the bird was terrestrial, incapable of flight, proportionately heavier and more sluggish than the ostrich, was vindicated by the discovery of the small and keel-less breast-bone, and by the relatively still smaller scapular arch, which, moreover, indicated an entire want of wings by the presence of a ridge where the socket for the main wing-bone should have been, and where it exists in the ostrich, and also in the apteryx, in which the wing is reduced to the smallest relative dimensions among existing birds. If any still smaller rudiments of a humerus should have existed, and have been suspended by ligament to the scapulo-coracoid arch, in *Dinornis*, such specimen has not yet reached me. Means of restoring the skull, the pelvis, the vertebral column, and the entire foot successively arrived.

The next and very remarkable kind of *Dinornis* was characterized by the relative thickness of the bones of the hind limb, and suggested the epithet *elephantopus.* This elephant-footed bird was as tall as an ostrich, but must have outweighed two, at least, of that largest of living birds—the "*Avium maxima*" of Linnæus. But I was favoured next to receive remains of a *Dinornis* which as much surpassed in size the *giganteus* as did this the *ingens.* Deeming then, as now, that the limits of bulk were surely reached, I committed myself to the *nomen specificum* of *Dinornis maximus.* Of this stupendous bird you may see the skeleton in the British Museum. I thought the articulated casts of that of the *Megatherium giganteum* a suitable equivalent, in which the accomplished founder of the Natural History Museum at Christchurch, Canterbury Province, South Island, concurred. Dr. Von Haast has had the same pleasure in adding that evidence of one of the hugest extinct mammals to his museum at the Antipodes as I have experienced in the addition, due to his discovery in the Glenmark swamp of the maximised Moa, of the skeleton of that bird in our National Museum at home.

The species of *Dinornis* now more or less completely restored are fifteen in number: viz., *struthioïdes*, *ingens*, *giganteus*,

dromioïdes, *casuarinus*, *rheïdes*, *crassus*, *gravis*, *gracilis*, *geranoïdes*, *robustus*, *elephantopus*, *curtus*, and *maximus*. The last two exemplify the opposite extremes of size in the extinct genus.

Our knowledge of these extinct wingless birds, is not, however, restricted to their osteology. Some have left their remains in caves, and under other conditions, which have enabled us to study and compare portions of their skin, and even their plumage. The feather, as in other flightless birds, had loose barbs, and it was provided with an after-shaft, two feathers growing out of one quill, as in the cassowary. Of the skin of the sole of the foot, and of the form and substance of the toes, I have had evidence from footprints in tidal clay, and from casts of such; I have also received evidence of the eggs of the *Dinornis*. Perhaps one of the richest localities of the remains of these extinct birds of New Zealand was discovered by the Rev. Richard Taylor, M.A., of the missionary station at Wanganui, near or along the shore at Waimate. "It appeared," he wrote, "to be a regular necropolis of the race." From this locality was obtained the specimens subsequently obtained by purchase from Mr. Walter Mantell, for the British Museum.

The spread of colonies in different parts of both islands of New Zealand, with concomitant growth on my part of correspondence and appeals for search, collection, and transmission of fossil remains, have resulted in a corresponding harvest of such evidences, from which, besides the confirmation and restoration of the above-cited species of *Dinornis*, indications of other extinct wingless or short-winged birds have been received. They have included two kinds of coot, one (*Notornis*), of the size of a turkey, the other (*Aptornis*), nearly as big as a cassowary; a third kind of bird (*Cnemiornis*), in the leg-bone of which characters like those of a natatorial bird (*Colymbus*) were pointed out,* was subsequently shown by Dr. Hector, of Wellington, New Zealand, who obtained an entire skeleton, in the North Island, to be most nearly allied to a large anserine bird (*Cereopsis*) still living in Australia.† But in the still larger extinct goose of New Zealand, as in the large coots and kivis, the wings had become too small for flight.

The most remarkable exception to this flightless character of the extinct birds of New Zealand was discovered in the Glenmark swamp, in the form of bones having the nearest resemblance to those of the Kahu Harrier-kite of the island (*Circus Gouldi*), but of a size surpassing those of the largest condor or

* "Trans. Zool. Soc.," vol. v. (1865).

† "Proc. Zool. Soc.," 8vo. 1874. "Wingless Birds of New Zealand," 4to. vol. i. pp. 238, 365; pls. lxvi.–lxx. xcv. ci. civ.

lammergeyer.* I suppose this huge bird of prey may have harried and carried off the chickens of the gigantic Moas; and that the extinction of the *Harpagornis*, as it has been termed by its describer, the accomplished naturalist, Dr. Von Haast, may have followed as a consequence that of its prey. So grand a bird of flight could hardly have escaped the notice of the natives with whom Banks and Solander communicated, or of such an acute ornithological observer as the monographer of the existing avifauna of New Zealand, Mr. Buller, of Wellington. It may be that some lingering tradition of the bird led the Maori, from whom the first indication of the fossils of New Zealand was obtained, to call it "the bone of a great eagle."

More than one story of still existing Moas have found their way into New Zealand newspapers; but, like those of the great sea-serpent, they lack the data requisite for scientific acceptance. In both cases the proper attitude of the naturalist is the "expectant" one.

When the first portions of the skeleton were described and figured in 1847, upon which the former existence of the great flightless coot of New Zealand was affirmed, the *Notornis* was concluded to have passed away as completely as the *Dinornis*. But it fortunately happened that Mr. Walter Mantell, visiting the south-west part of the South Island, in 1849, came upon a party of seal-fishers who had captured the living bird on the shores of Dusky Bay, and had luckily kept the skin after cooking and eating the unique specimen. The skull and leg-bones brought to London with this served to identify the species and genus; the skin, beak, and feet confirmed the inference from the fossils. This specimen of *Notornis Mantelli* was purchased by the British Museum, where it may now be seen.†

I suppose that any captor who should bring his *Dinornis* alive to London might reckon upon a rich reward from the Council of the Zoological Society.

At present all I have been able to get, besides the bones, have been brains,‡ rings of the wind-pipe,§ gizzard stones,‖ eggs, feathers,¶ and bits of skin,** of unquestionable Moas. But how about the brain, it may be asked, unless you had a fresh bird? A very pertinent question. The brain is represented by a cast of the interior cranium. It is relatively smaller than that of

* Op. cit. vol. i. p. 141; pls. cv. cvi. cvii.

† *Notornis Mantelli* is figured of the natural size as frontispiece to my work (4to. 2 vols. 1879), "On the Extinct Wingless Birds of New Zealand."

‡ Op. cit., p. 326, pl. xci. fig. 11.

§ Ib., p. 327, pls. xcii. xciii.

‖ Ib., p. 337, pl. xcii. fig. 8.

¶ Ib., p. 440, pl. cxiv. figs. 8–11.

** Ib., p. 443, pl. lxxi. and pl. cxiv. fig. 7.

the ostrich, which is reckoned the least intelligent of living birds.

My first acquaintance with the eggs of *Dinornis* was founded on the fragments of the shell obtained from ancient cooking-pits.* Thereupon I broke up an ostrich egg into similar fragments; then compared the curves of their outer surface. The long and the short diameters, *i.e.* the longitudinal and the transverse dimensions of the egg, were thus indicated in the ostrich fragments; by like indications in those of the bits of the *Dinornis* egg-shell, I recomposed the longitudinal and transverse contours of the entire egg, as shown in Plate XC. of the undercited work; and such egg I hypothetically referred to the *Dinornis elephantopus*.†

In the year 1865 the entire egg of a larger species was sent to London, and submitted to my inspection. It fetched 100*l.* at the sale by auction at Stevens's rooms. Its history is as follows:—A colonist, digging the foundations of a store at Kaikoura, Canterbury, New Zealand, came upon the skeleton of a Maori, who had been buried in a sitting posture, and upon his lap had been placed, at the interment, this egg. His greenstone adze was also found in the grave. From the superiority of length of this egg to that ascribed to the *Dinornis elephantopus*, with a minor degree of transverse diameter, I conceived it might belong to the taller and less robust species, *Dinornis ingens*.‡ I subsequently received from Dr. Hector intelligence of the discovery of an egg of the *Dinornis crassus*, containing some bones of a partly-hatched chick; they included a sternum, pelvis, coraco-scapular arch, showing the unequivocal characteristics of their genus,§ but no wing-bones. On these and some other data I have formed an estimate of the size of the egg of the *Dinornis maximus*, at sixteen inches by twelve inches in the two diameters.‖

The living Kivi (*Apteryx*) is remarkable for the large proportional size of the egg, of which it lays but one at each procreative season. It is probable that its extinct gigantic kindred could as little afford a relatively greater incubating area to the shelly case of their embryo.

Of the numerous transmissions from divers localities in both islands of New Zealand, not any have included a bone of a land-mammal having any claim to be considered an aboriginal

* "Proceedings of the Zoological Society of London," Part xx. 1852, p. 12.

† "Memoirs on the Wingless Birds of New Zealand," 4to. vol. i. p. 317, pl. xc.

‡ Ib., p. 318, pl. cxvii.

§ Ib., p. 319, pl. cxv.

‖ Ib., p. 320, pl. xcix.

species, or belonging to one which has become extinct, and would have been otherwise unknown. Now and then, though rarely, the bone of a rat, of the Maori dog, and of a seal could be picked out.

New Zealand never had an indigenous Mammalian fauna comparable to the rich Marsupial one of Australia. A bat or two flits in its atmosphere, seals haunt its coasts, and thereupon is occasionally stranded the carcase of a whale.

When the Maori first landed he found no kangaroo or other herbivorous beast to yield him flesh. The sole source of that food, the more needed from the absence of the bread-fruit and cocoa-nut trees which he had left at Hawaii, and the colder climate of the land to which he had been driven, was in the various kinds of huge birds incapable of flight. These, it is evident, had overspread both islands. The rich development of ferns, with nutritious elements in unusual proportion in the roots, of which the Maoris still avail themselves for their favourite bread, formed a perennial table for the support of the feathered bipeds, to which divers other kinds of vegetable nourishment were doubtless added.* Foot-prints on the sea-shore suggest their varying their diet by picking up marine animals. For how many centuries before the unfeathered biped appeared the Dinornithidæ had roamed supreme over the islands there are no adequate grounds for estimate.

There are evidences of different kinds that the extirpation of the extinct birds of New Zealand was the work of man.† The question of the origin of these wingless species is a deeper one. Into that I have entered, as far as there seemed to be any data for guidance, at the conclusion of the work on the subject of the present section of the communication now offered to the Institute.‡

AUSTRALIA.

I finally proceed briefly to state the chief results of palæontological research in the Colonies of Australia, restricting the present notice to the extinct species of the Mammalian class. The labours of zoologists in the discovery and determination of the existing kinds have made generally known the fact of the prevalence in the Australian continent of the peculiar group called Marsupialia, or pouched beasts; those, viz., which produce their young prematurely as compared with the rest of the class, and transfer them to a skin-bag covering the teats, to which the embryo remains attached till it gains the size and

* See the section "On the Food, Nests, and Traditions of the Moas," Op. cit. vol. i. p. 450.

† Ib.

‡ Op. cit. vol. i. p. 460.

strength of the ordinarily born young in the more highly organized or placental Mammalia. But one existing genus of these Marsupials is known elsewhere in the world—the opossums, viz., of America (*Didelphis*, Linn.). Our knowledge of the various modifications of the Didelphs of Linnæus has been derived exclusively from the remnant of that vast Melanesian continent of which Australia, Tasmania, New Guinea, and a few outlying insular fragments now remain. The carnivorous kinds are represented by the Tasmanian Thylacine, of the size of the wolf, by the somewhat smaller Sarcophile or Devil of the Tasmanian colonists, and by still smaller Dasyures or native cats and weasels of Australia. The insectivorous kinds are represented by the bandicoots (*Perameles*, *Myrmecobius*, *Chæropus*); the frugivorous species by the arboreal phalangers, koalas, and petaurists; the root-eaters by the burrowing wombats; the grazers and browsers by the numerous and varied family of the saltatory potoroos and kangaroos. The largest existing marsupial in Australia is the Boomer kangaroo (*Macropus major*). The skull of the biggest kangaroo which has come under my observation does not exceed eight inches in length. Such a kangaroo will outweigh by one-half the biggest thylacine.

John Gould, in his beautifully illustrated work on "The Mammals of Australia," gives the length of 2 ft. 2 in. to the wombat of Tasmania (*Phascolomys ursinus*); the bones of the *Phascolomys latifrons* of the Australian continent indicate a somewhat larger animal, but the skull scarcely exceeds 7 in. in length. The skull of the largest of the extinct wombats is more than a foot in length.

Between this and the largest existing wombat were two other species of intermediate dimensions; there were also wombats distinct in kind, but resembling in size, the two or three existing species; finally, there existed a smaller species in Australia. All these have passed away. Admitting the specific distinction of the two kinds of wombat now living in Australia, and that of the sole existing Tasmanian species, fossil remains have made known the former existence of seven kinds which have become extinct. These wombats ranged from the size of a marmot to that of the European bear (*Ursus arctos*), and the distinctive characters of the largest kind are of generic value.

The fossil evidences of kangaroos are more abundant and varied than those of the wombats. I shall limit myself to a brief notice of the larger extinct kinds.

I have referred to the dimensions of the skull of the biggest known existing kangaroo.

The first extinct species represented by the fossils obtained by Sir Thomas Mitchell, from the caves of Wellington Valley, had a skull of 10 in. in length. I called it *Macropus Titan*,

not anticipating in 1836 to find it but a middle-sized species. Subsequently I received evidences of a kangaroo with a skull of 12 in. long; and next, of one with a skull as large as that of a full-sized ox, 16 in. in length.

Now, these extinct species do not differ merely in magnitude from each other, and from the smaller existing kinds, but in modifications of the teeth and in the proportions of the limbs.

As the kangaroos gained in bulk they lost in power of leaping. The hind limbs were less disproportionately long, the fore limbs less disproportionately short. Both pairs took a more equal share in the support and progression of their bulky frames. Nevertheless, all the well-marked characteristics of the macropodal foot were retained, the modifications being restricted to those of size and proportion of toes and leg-bones.

So likewise with the teeth. Certain teeth of extinct kinds were shaped for cutting, the same teeth in other kinds for pounding.

Species not exceeding or inferior in size to existing kangaroos manifested specific distinctions in the teeth, in the skull, and in parts of the skeleton. I have had to name and characterize a score of kinds of kangaroo that have existed in Australia and have passed away; and these extinct species have made known to the zoologist seven generic modifications of the macropodal family, distinct from any of the genera still represented by known living kinds of kangaroo.

The most interesting result of these comparisons of the fossil remains of kangaroos were the indications of a gradual resumption of the more ordinary quadrupedal character in the larger extinct species. This transition I found to be completed in still larger forms which retained, in the main, the macropodal type of dentition, the modifications of the teeth indicating a more strictly herbivorous character of quadruped.

The first of these forms was manifested under three specific modifications, on which have been founded a *Nototherium Mitchelli*, a *Not. Victoriæ*, and a *Not. inerme*. Of this genus I have as yet, indeed, obtained little more than portions of the skull and teeth. But a few detached bones of the ankle show a deviation from the kangaroo type of foot toward that of the ordinary character, and an arm-bone indicates a more equal size with stouter proportions of the fore and hind limbs. I infer the *Nototherium* to have resembled in general character a large tapir, but it was essentially a marsupial quadruped.*

Amongst the cave-fossils submitted to me in 1835 by Sir

* An entire skull of the *Nototherium* has been discovered. It is now in the Museum of Natural History at Sydney, the Trustees of which have transmitted a cast to the British Museum.

Thomas Mitchell, and which are described and figured in the "Appendix" to his "Three Expeditions into the Interior of Eastern Australia" (2 vols. 8vo. 1838) was the fore-end of one-half of a lower jaw with the implanted end of a fractured tusk. It indicated a beast as big as a hippopotamus. This fossil and a limb-bone, sent to Paris, of what I subsequently determined to belong to the same species, had given rise to the notion that a true hippopotamus and an elephant had left their remains in the caves and drift deposits of Australia.*

After an extensive and minute comparison of the tooth-stump from Wellington Valley with every quadruped of similar size having such a tusk at the fore part of the under jaw, I came to the conclusion that it must have belonged to a distinct kind of animal; that the tusk had been one of a pair like the lower incisors in the kangaroos, wombats, and phalangers; and that the fossil, therefore, indicated the former existence in Australia of a marsupial quadruped as big as a rhinoceros or hippopotamus; but, being of a distinct genus and species, I described and figured it as representing a new form—*Diprotodon australis*.

But what would this problematical *Diprotodon*, guessed at by a bit of a tooth, turn out to be?

Now, here I may remark that there is no chase in the sporting world so exciting, so replete with interest, so satisfactory, when events prove one to have been on the right scent, as that of a huge beast which no mortal eye will ever see alive, and which, perhaps, none ever did behold!

Such a chase is not ended in a day, a week, or a season. One's interest is revived and roused year by year as bit by bit of the petrified portions of the skeleton come to hand, and thirty such years elapsed ere I was able to outline a restoration of *Diprotodon australis* such as is shown in the plate of the work† now submitted to the Institute.

The dental formula of the *Diprotodon* is that of the nototherе and of the kangaroo, namely, $i\,\frac{3-3}{1-1},\quad c\,\frac{0-0}{0-0},\quad m\,\frac{5-5}{5-5}, \quad = \quad 28.$ The true molars have the crown cleft into two strong transverse ridges, also the fundamental pattern of those teeth in the kangaroos. But the skull of the *Diprotodon* is a yard in length.‡ The thigh-bone might well suggest to the Parisian palæontologist the idea of an elephantine quadruped. The fore limbs and hind limbs are of equal length. The animal must

* See Lyell, "Principles of Geology," 8vo. ed. 1835, p. 143.

† "Researches on the Fossil Remains of the Extinct Mammals of Australia: with a Notice of the Extinct Marsupials of England." 4to. 2 vols. 1877. (Erxleben, 2 Henrietta Street, Brunswick Square.)

‡ See Frontispiece of the above work.

have trod the ground like a heavy pachydermal brute. Yet there are multiplied proofs in its skeleton that it carried its young in a pouch, and that it belonged to the prevalent characteristic type of suckling beasts in Australia—that it was, in fact, the giant of the Marsupial order.

In wild nature a balance is maintained between the flesh-makers and the flesh-eaters. The teleologist expatiates upon the beneficence of the check interposed by Providence upon the undue increase of the vegetable feeders through the contemporaneous existence of their devourers.* In Australia, at the present period, the wild or native browsers and grazers are in excess.

The native or aboriginal carnivora are now too few and too feeble to keep the herds of kangaroos in due check. The largest known existing native carnivore in Australia is the so-called "native cat" (*Dasyurus macrurus*).

In the smaller adjacent insular tract of "Van Diemen's Land," or Tasmania, although there be no kangaroo exceeding the Australian rufous kind in size, there are two kinds of indigenous Marsupial carnivora larger and more destructive than any known to exist in the more extensive continent. One of these is the so-called "Devil," the other the native hyæna. The zoologist substitutes for the colonial vernacular appellatives his descriptive Greek compounds. *Sarcophilus*, or "flesh-lover," designates the mischievous, untamable brute which might weigh down a jackal, though of more compact and robust build; *Thylacinus*, or "pouched wolf," or "hyæna," is the name by which the larger striped sheep-worrier is known to science.

Strange that neither of these "checks" should exist in the wider field, to operate upon the manifold herds of marsupial herbivores of the larger continent! Stranger still if the balance or check had never been interposed during the old times, when the larger kinds of kangaroo and their huge, even gigantic, congeners browsed the scrub or grazed the prairie over the length and breadth of the Australian continent.

The following is the account which the palæontologist has to render on this subject. Mitchell's gatherings in the breccia clefts and hollows of the limestone rocks in Eastern Australia included remains of both *Sarcophilus* and *Thylacinus*, corresponding in bulk and specific characters with the species still existing in Tasmania. Considering the size of these carnivores, their audacity, the damage which the larger one inflicts upon the flocks of the Tasmanian colonist, and the stupid pertinacity with which the smaller "devil" devastates

* Buckland, "Bridgewater Treatise," vol. I.

his poultry-yard, it is not likely that either species would have escaped the notice of the Australian settler if it had lingered on to be a pest, or an ally, to any of the great Colonies of that continent.

I conclude, therefore, that both the species have become extinct in Australia, and that they formerly existed there as they still exist in Tasmania. Moreover, in addition to the cave specimens, I have received evidences of both *Thylacinus* and *Sarcophilus* from the drift deposits and beds of rivers in several and distant parts of Australia. And these fossils, besides testifying to species undistinguishable by tooth and bone from the Tasmanian kinds, indicate others of larger size, which have never been observed living. Of *Sarcophilus*, of which the present ursine kind might be matched by a jackal, I have had evidence of a species (*Sarcophilus laniarius*) as big as a leopard. Of *Thylacinus* I have also fossils of a larger than the existing kind, equalling a panther in power (*Thylacinus major*). Neither of these extinct Australian carnivores, however, bore the proportion to the nototheres and diprotodons which the South African lion bears to the buffaloes, elands, and other great herbivores upon which it preys.

Something still seemed wanting in the proportion of the beasts of prey to the beasts which converted the grass and herbage of the field into flesh in these ancient epochs of Australian life.

Now, among the fossils submitted to me by Major Mitchell, in 1835, was a tooth which, from its resemblance to that called the "carnassial" or "flesh-cutter" in the lion's jaw, raised a suspicion that there had existed in Australia a carnivore exceeding in size the largest of the extinct Thylacines. But a comparison of this solitary fossil with all the modifications of the teeth in the various existing kinds of Marsupialia, had made me acquainted with a somewhat similarly shaped sectorial tooth in certain small phytophagous and mixed-feeding genera. I could not, therefore, give undue weight to other resemblances supporting only a conjecture. Additional discoveries might supply the required test, and were to be waited for. If the large fossil sectorial tooth in question was the premolar of a gigantic phalanger or potoroo, it must have been preceded by teeth shaped for cutting and nibbling, and have been followed by several large flat or ridged broad molars for crushing and grinding. If the large sectorial tooth was a premolar of a carnivore, it must have been preceded by teeth for piercing and holding, and have been followed by molars small in size and few in number, tubercular in shape, and adapted at best for pounding gristle or tendon.

Pending, therefore, the possible acquisition of specimens

yielding the required dental evidence, I contented myself with giving figures of the tooth in question,* in order to attract attention to any fossils which might show such a tooth associated with more of the animal's dentition.

In the course of a few years I received the requisite evidence. First, in the form of a lower jaw, from the bed of the Condamine River, Queensland; next, in that of a mutilated skull, from the bed of a lake eighty miles south-west of Melbourne; and subsequently, by more perfect specimens demonstrative of the super-carnivorous character of the dentition of the extinct beast, which thereupon I called *Thylacoleo*, or pouched lion. Teeth like the canine tusks of the lion precede the carnassial tooth first discovered; that tooth is followed, also as in the lion, by one small tubercular tooth in the upper jaw, opposed to two smaller tuberculars in the lower jaw; the carnassial of that jaw worked upon the upper one like a shear-blade, and the extensive and smoothly worn surfaces are matched by those of the flesh-cutters in old lions and hyænas of the present day.

Thus it appears that Australia was formerly inhabited by mammals of the peculiar marsupial type, not only varied for predatory and herb-eating life, but exhibiting their type under dimensions as varied as are the higher or placental wild beasts of the larger continents of the globe. Creatures nearest of kin to the Australian forms, and, like them, marsupial, have indeed lived and bred on land which now forms part of the island of Great Britain. Fossil remains of a carnivorous mammal with a dentition most nearly like that of *Thylacoleo*, have been discovered at Purbeck, on the Dorsetshire coast. Fossil remains of an insectivorous marsupial, many-toothed like the Australian *Myrmecobius*, have been found in Oxfordshire, in the slates of Stonesfield. Both these localities are of the middle or "Mesozoic" period in geology, and I may give an idea of their antiquity by saying that not a particle of the chalk cliffs or "bushless downs" in England had been formed when the old pre-Britannic continent flourished which, in its vegetation, its shells, the fishes of its sea-shore, and the beasts of its fields, bore the nearest resemblance, in fauna and flora, to the antipodean seat of our present flourishing Australian Colonies. We are now superseding there the Oolitic types, which alone presented themselves to the naturalists of Cook's voyage, by the higher forms of vegetable and animal life that have lent themselves, or been by man adapted, to his special needs in Asia and Europe.

But the kangaroo, which Banks and Solander first saw, and thought to be a huge bird as it hopped out of their ken into the

* Plate xxxii., figs. 10 and 11, of Appendix to the "Three Expeditions," &c. 8vo. 1838.

scrub, was actually the largest marsupial quadruped that at that date existed in Australia.

At what period became extinct those huger forms of marsupial life which palæontology has made known to us? To what cause is due the extinction in Australia of the diprotodons, the nototheres, the thylacoleons, the phascolones or gigantic wombats, the palorchestes, procoptodonts, protemnodonts, sthenurans, with the thylacines and sarcophiles which alone of all the preceding marsupials still linger on in life in the neighbouring island of Tasmania?

No other extirpating cause has suggested itself to my mind save the hostile agency of man. No evidence of diluvial catastrophe or of climatal change has been discovered to account for the disappearance, for example, of the *Macropus Titan* and the survival of *Macropus major*.

To a race of men depending, like the "black fellows," for subsistence on the chase, the largest and most conspicuous kinds of wild beast first fall a prey. The smaller kinds, with swifter powers of locomotion, more easily conceal themselves and escape.

True it is that, as yet, no evidence of the ancestry of the existing aborigines of Australia has been detected in the caverns which have yielded fossil remains of their hypothetical prey. But such caves, if explored with due care, skill, and method, may bring to light, as they have done in England, indubitable evidences of the pre-Adamatic or pre-historic men of Australia; the extensive shell-mounds attest the enormous period during which these primitive people roamed over that continent.*

In conclusion, I may remark that at the commencement of my application of anatomical knowledge, fifty years ago, to the reconstruction of extinct species, not one of the classes here treated of was known to have lived in any of the three great Colonies which I have selected for this evening's discourse.

What, then, may be expected from analogous researches and collections of the fossil remains in the caves, drifts, and tertiary deposits of New Guinea? As we learnt from the admirable Paper to which I was privileged to listen at a former meeting of this Institute, we may infer from the varied configuration of New Guinea, from its mountain ranges and concomitant streams and rivers, its caverns, doubtless opening into defiles and valleys, its latitudes, involving conditions and stimulants of life surpassing those under which the beasts flourished on whose remains Colonial palæontology has been hitherto exercised, that there is

* In 1869 the Parliament of New South Wales voted the sum of 200*l.* in aid "of a careful and systematic Exploration of the Limestone Caves of Wellington Valley."

a promise of results which will exceed in novelty, in singularity, and variety of vertebrate structures all that has been contributed from Australia and New Zealand towards a philosophical comprehension of the scheme and origin and progress of animated nature.

IS NEST-BUILDING AN INSTINCT IN BIRDS?

By BENJAMIN T. LOWNE, F.L.S.

MR. ALFRED R. WALLACE, in his contributions to the theory of natural selection, has an essay on the philosophy of birds' nests, in which he controverts the doctrine, which he admits to be almost universally held, that birds build their nests by instinct; and he believes that both birds and men, in a primitive state, build by imitation. He says, "It will be objected, that birds do not learn to make their nests as man does to build, for all birds will make exactly the same nest as the rest of their species, even if they have never seen one, and it is instinct alone that can enable them to do this. No doubt this would be instinct, if it were true, and I simply ask for proof of the fact; this point, although so important to the question at issue, is always assumed without proof, and even against proof, for what facts there are are opposed to it. Birds brought up from the egg in cages do not make the characteristic nest of their species, even though the proper materials are supplied to them, and often make no nest at all; but rudely heap together a quantity of materials: and the experiment has never been fairly tried of turning out a pair of birds so brought up into an enclosure, covered with netting, and watching the result of their untaught attempts at nest making."

I have lately had the opportunity of making the experiment, which Mr. Wallace states has never been fairly made; and much to my surprise, for a year ago I fully believed Mr. Wallace was right, the results are at complete variance with the opinion which Mr. Wallace has promulgated upon this subject. I will give the details of my experiment in full, reserving all comment until I have done so.

Last spring I received a pair of young ring-doves (*Columba risoria*), in their first plumage, which had been hatched in the breeding-box of an ordinary dove's cage, upon a straw nest built on the floor of the cage. These were a male and a female; but at the time I received them they were so young that I came to

the conclusion, from their very quarrelsome habits, that they were of the same sex; in consequence of this opinion, which I afterwards found to be erroneous, I asked the lady who gave me the first pair to give me another young dove. She gave me one brought up in the same manner. I kept these three doves in a wire cage until this spring. The exact size of the cage was three feet by two, and two feet high. They turned out to be a cock and two hens. At the end of February each hen laid two eggs on a bundle of hay placed in one corner of the cage; but there was not the slightest attempt at nest-building, although they played with the hay, carrying about a piece in their bills by the hour together. The females sat by turns with the male, and in due time three of the eggs hatched. Although some interesting facts were brought to light in the rearing of these young birds, it suffices to observe in the present connection, that only one of the young birds became fully fledged, the others died from heartless neglect on the part of the parents, apparently because they were feeble and two days younger than the chick that was reared.

In the middle of April I turned the three birds out into an aviary in the open air, in which there was a large branch of a tree with numerous twigs and buds to serve as a perch. The highest branchlets of this were about nine feet from the ground.

I provided the birds with a double breeding-box, similar to the one in which they were themselves hatched, in one side of this I placed a handful of hay, together with their newly fledged offspring. I left the other side empty, in the expectation that they might possibly build a nest of hay or straw, and I supplied them with both materials. The young dove learned to fly in a few days, and slept in its box at night, its parents and foster-mother fed it continually in the nest-box; but there was no attempt to make another nest in the box.

About a week after I placed the birds in the new aviary they took possession of the highest twigs of the tree branch, each with a small piece of stick in its bill; as I judged they intended to build in this portion of the tree, I at once supplied them with a number of twigs; these were nearly all straight twigs of varying length and thickness, without any lateral branches; but amongst them were a few pieces, each with a short lateral branch, which were at once collected by the doves, and carried to the place they had selected for their nest; but they evidently had not the slightest idea of the use of the sticks they had selected. They tried in vain to fix them to the wall of the aviary or to its roof, almost always to the latter, and waved them about above their heads until they dropped them. I thought that they might be in the habit, in nature, of laying the foundations of their nest in twigs above their heads, so I fixed some perches below the cleft

in the tree which I thought they had selected to build in, and wove two or three small branches in such a manner as to afford them a choice of resting-place, and also to catch the sticks they dropped. I ought to have mentioned, that the birds were excessively tame, having been brought up in the house, and that I was constantly in the habit of taking them from their cage and playing with them, hence they allowed me to stroke them or handle them without fear, so that my interference did not disturb them. As soon as I had finished, the male bird found the new place, and cooed in evident delight, and he was immediately joined by the two hens, each with a stick.

After vainly endeavouring to lodge the sticks above their heads for a couple of hours, sometimes from the old and sometimes from the new resting-place, and dropping them, they gave up work.

I now, however, observed that all the cleft and branched sticks had been gathered from the bottom of the aviary and lodged amongst the branches near the top of the tree. I also observed that the birds every now and then picked up a stick, balanced it for a little time in their bills, and then dropped it again. The thought struck me that straight sticks and twigs would not do, so I collected a number of forked branches and branches with lateral twigs. No sooner were these thrown into the cage, than the birds made their usual crowing noise and resumed work. As soon as all the branched sticks were used, they at once ceased work, although there was an abundance of unbranched sticks of suitable size in the cage. The end of all this was, that in three days, they had finished a nest exactly like that of a wood pigeon. They lined it neatly with straw, and ornamented it with some tufts of the dried flowers of the sugar-cane (*Saccharum officinale*), which I took out of a vase in the drawing-room, and broke up, as I thought the soft feather-like flowers of the grass would make a good lining to the nest. They did not use it, however, for this purpose, but let a few pieces hang over the edge of the nest, with a great deal of straw, perhaps for the purpose of concealment. Each dove laid two eggs in the nest, and they are now sitting by turns with the male.

The apparent use of the side branches on the twigs which they use is to peg the nest together, as these hang down and pass through the meshes of the sticks which are already laid.

The important facts to my mind are, first, these birds had never seen a tree, or, at least, sat on one, yet they selected a place nine feet from the ground for their nest. They had never seen twigs, and could have no experience in the use of lateral branches, yet they carefully selected these and no other. Secondly, they had apparently no idea of the use to put the sticks to, when they had selected them, unless they are in the

habit, in a state of nature, of starting the nest on branches above their heads. As soon, however, as a few branches had lodged below them, they finished the nest, which accident had commenced for them. Thirdly, they followed the habits of the species to which they belong, although it is probable that these habits had been in abeyance for many generations, and certainly they had been in abeyance for more than one generation. Fourthly, the conditions were present which would have enabled them to breed in the same kind of nest as that in which they were themselves brought up, and in which they had already reared a young bird. Lastly, these birds were very tame, so that if new conditions could have modified their natural habits, this was a case in which we might have expected modification, as all the circumstances were in favour of a perversion of natural habits.

I do not know how to account for the fact that these birds built a natural nest. And I may be hasty in my conclusion, but I am in my own mind convinced that we have here an instance of what is usually called Instinct. This conviction is the more important because it is not a year ago since I gave a lecture in Great Ormond Street, at the Working Men's College, in which I maintained the view that animals act in such cases entirely by reason and experience; and at that time I felt certain from all I knew that Mr. Wallace was right, or nearly right, in his views.

The whole phenomenon had a striking similarity to the slow return of memory, brought about by a series of associations. There can be no doubt as long as the birds remained in a comparatively confined space, without the use of their wings, and without a natural branching tree to build in, they would never have built a characteristic nest. My own belief is, that the tree acted as a stimulus to their instinct, and that the natural surroundings prompted them, as it were, and awakened their dormant inherited powers. Although my impression is, that the final site of the nest was determined by the place where the sticks fell, which they failed to fix above them, I am by no means assured in my own mind that even this was not determined by a subsequent awakening of an instinctive act, and that the sticks were intentionally dropped upon the branch below them. The want of readiness in some things which these birds exhibited at first can hardly be considered surprising, when we remember the number of generations in which it is probable no natural nest had been built. Indeed, it is quite possible, and I think even probable, that their progenitors had laid their eggs on hay or straw on the floor of a dove-cot for fifty years or longer.

The importance of these facts can hardly be over estimated,

as they bear upon the theory of innate ideas, or at least of innate genius. From the foregoing experiment the conclusion is very tempting, that the birds are endowed with special faculties and ideas, just as it appears that men are born with a special aptitude for certain acts, both mental and physical, and that mind is endowed with properties of a special nature; at least, they are of great interest because they are facts which ought not to happen, according to the theory which is daily becoming more fully received. They belong to one of those by-paths of Biology, which it is Mr. Wallace's delight to tread, and in which he has done such excellent work.

THE POSITION OF THE SILURIAN, DEVONIAN, AND CARBONIFEROUS ROCKS IN THE LONDON AREA.

By Robert Etheridge, F.R.S., etc.

[PLATE VII.]

AS long ago as 1856 a distinguished author and physicist communicated to the Geological Society a remarkable paper upon "The possible extension of the Coal-Measures beneath the south-eastern part of England." * Speculative as those views and generalizations then seemed to be, they but foreshadowed, and almost foretold, what of late has been to a great extent realized.

Competent geologists were then appealed to, to admit the broad generalizations put forth as to the extension from the Continent (Belgium and France) of the older rocks (Coal-Measures) beneath the superincumbent strata of London Clay, Chalk, Gault, Lower Greensand, and Wealden, in the south-east of England generally.

This problem was then, as now, of national importance, and gave rise to much speculation as to the continuity of certain formations or rock masses occurring beneath the German Ocean, from the Belgian and German areas, and also under the English Channel from the north-east of France. Although Mr. Austen's paper bore the title of the "Possible extension of the Coal-Measures beneath the south-eastern part of England," it had a far wider and greater significance than at first sight appears, it being certain that with the occurrence of any such extension of the Carboniferous rocks from Western Europe we should expect still older Palæozoic rocks to be more or less associated with them. This now turns out to be true, so far as the two older groups, the Devonian and Silurian, are concerned; the Devonian occurring immediately beneath the Cretaceous group in London, and eighteen miles north of it, at Turnford, near Cheshunt; the other, the Wenlock Shale (Upper Silurian), having lately been determined at Ware, immediately below the Gault, and penetrated about 25 feet. No less than thirty species of fossils have been determined from the cores brought up.

* R. Godwin-Austen, Esq., "Quart. Journ. Geol. Soc." vol. xii. pp. 38–48.

Looking at the physical structure of the south-western and north-western part of England, and the great mass of the older Palæozoic rocks of North and South Wales, it is evident that from the Cheviots to Cornwall the oldest rocks in Europe are exposed, hidden only in places by a mantle of superficial glacial and river drifts. The eastern sides of the exposed Northumberland and Yorkshire coalfields, down to the latitude of Nottingham, are covered and deeply buried by the Triassic, Jurassic, and Cretaceous rocks; south of Nottingham these old land areas are again exposed. The Charnwood rocks, of *unknown age*, and the associated coalfield of Ashby-de-la-Zouch, with the Warwickshire and South Staffordshire coalfields, stand out like islands in the midst of the great Triassic plain of mid-England; they are the last isolated exposures or remnants of Palæozoic land seen south and east of the great Pennine axis.

The entire mass of North and South Wales stands out in bold relief westwards of the Severn Valley and the stunted hills of Cheshire. The Old Red mountains and Silurian rocks which border the northern edge of the great Welsh coalfield, as well as the Devonian promontory of Cornwall, isolated as they appear to be through the unconformity of the Secondary rocks which constitute the eastern half of England, are only apparently so through this great overlap. Could we uncover and expose the old Palæozoic floor or land surfaces on which they rest, with all its irregularities, doubtless we should find that the eastern face of the Palæozoic plain would stretch away under the north-eastern and south-eastern counties and German Ocean,* filling up the irregularities in the old land surface made either by the denuding agency of the secondary seas during the slow depression of the area they then occupied, or they were previously sculptured and fashioned into hills and valleys at the close of this early period, and prior to the deposition of the Secondary or Mesozoic rocks.

The area on which the British Islands stand is an elevated yet submarine plateau, extending westwards from Ireland some 100 miles, and eastwards to Holland, north to Scandinavia, and southwards to a deep region west of France and Spain. The western face of this plateau, now beneath the sea-level and covered by the Atlantic, has a steep and rapid slope to the profound depths of that ocean. On the eastern side of England, on the other hand, the German Ocean, with its irregularities of sea-bottom, scarcely averages 100 feet in depth, and this shallow sea and the east of England unites us to the European plain. It is upon this plateau that all those changes of level, great and small, change of life,

* See Section No. 4, Pl. VII. Ideal section by Professor Hall, showing the prolongation of the Silurian, Devonian, and Carboniferous rocks eastwards, and the probable irregular surface of the Palæozoic rocks, now covered by nearer deposits. ("Coal-fields of Great Britain," p. 475).

or change of fauna—indeed, all the physical history of the British Archipelago—have taken place, on which have been modified the shape, size, and life history of the British Islands through all time, and by it we have been united countless times to the continent of Europe and probably to America. The Irish Sea and German Ocean or North Sea, and English Channel are now the one a shallow the other a deep hollow in the land, filled by the waters of the great Atlantic to the west, their beds being only a question of level.

An elevation of the bed of the German Ocean, or that part of the plateau, 100 feet, would unite us again to Europe; and some 300 or 400 feet would unite England to Ireland, and less than half that to France. A depression of one-eighth of a mile, or 600 feet, would render us an extensive archipelago, when nearly all the centre of England would be submerged. The Welsh and Cumbrian mountains, the Pennine chain, much of Scotland, and the bold coast-line of Ireland, would stand out as islands. The Hebrides, Shetland Isles, and those off the west coast of Scotland, are only outliers of the main land, evidences of change, mountains in the sea; the valleys being pasture land and feeding ground for dwellers in the ocean, nurseries for the fauna and flora of the sea, yet if the bed of the North Atlantic area were elevated but a comparatively few fathoms they would no longer be islands. It was upon this British and European plateau, then a land surface, that our coal growths and coalfields had their origin, growth, and development, stretching far away to the eastward in Europe, to Mons and Liége, and onwards as far as Westphalia, doubtless as one continuous terrestrial surface. Movements or oscillations of level through depressions and elevations greater than the present depth of the Atlantic, did then and have since repeatedly occurred, and most if not all the phases in the physical history of the British Islands have been governed and modified upon this area between the 500 fathom level off the western coast of Ireland and the flats of Holland and Belgium.

Such changes are still in action although slow. Unceasingly they go on, time only being required to do again all that had been done before. The sea, with its tides and ceaseless action, is both destroyer and preserver; it carves and denudes coast lines into shape, modifies sea bottoms, and, aided on the land by meteoric action through the agencies of rain, frost, ice, wind, and sunshine, fashions into contour the form of the mountain, curves of the valley, and depth of the gorge. The creeks of the Australian and cañons of the American are but terms for phenomena produced by rain and river action governed by time.

The above generalizations tend to lead us to the physiography of the older continents and areas, or those of Palæozoic and

Mesozoic times, to be determined and understood only through the application of modern laws, or as read by recent physical geography, which applied to the past enables us to read with tolerable accuracy, even at great depths, the configuration and condition of those areas once at or near the surface, but now deeply hidden, and revealed again in part through the application of the boring-tool in our search either for water or for mineral wealth.

As far back as 1856, Mr. Godwin-Austen almost asked for a practical solution of his views. "What is now," he says, "above measure needed is, that we should *obtain one single point of verification as to the depth at which any part of the Palæozoic group occurs beneath our south-east area.* The state of the question is such, that from this one single point, once ascertained, the rest of the investigation might be conducted, for practical purposes, with perfect certainty, and it is therefore of importance that the question and its possible results should not be lost sight of by all those who may be promoting deep sinkings at any places over the area which has been here indicated."

Again, Mr. Prestwich, in 1872, in his admirable article "On the probable existence of coal measures in the south-east of England," * speaks regrettingly of the fact that up to that time, "in this country, the newer strata overlying the Palæozoic range have been sunk into without result in the Wealden at Hastings to a depth of 486 feet; at Earlswood, near Reigate, in the same strata, to about 900 feet; through the chalk at Chichester to 945 feet; and at Southampton through tertiary strata and chalk to a depth of 1,317 feet. Unfortunately, all these works fall short of the mark which geologists wish to attain."

In continuation Mr. Prestwich remarks 'that in an industrial point of view no experiments could be more important than such as would serve to determine the position of this great underground range of older rocks, connecting the Ardennes and the Mendips. We have ascertained that it lies at no great depth beneath the overlying newer strata, and if the strike of the line of disturbance were in a straight line we should have no difficulty in determining its course.' Local deflection may have affected its east and west bearings through its range of 800 miles; and, "whilst Mr. Godwin-Austen would place the supposed coal trough in the Valley of the Thames, or under the North Downs," Mr. Prestwich would prefer placing it further north, in Essex or Hertfordshire; and whilst also Mr. Austen believed it to be continuous or extended, Mr. Prestwich favoured the idea that it is probably broken up into basins. "If, however," he says, "the axis of the Ardennes consisted of an anticlinal line,

* POPULAR SCIENCE REVIEW, vol. xi. p. 241. 1872.

the problem would be simplified, but it consists of a series of such parallel lines, and therefore whether or not the one which traverses the Boulonnais, and is probably prolonged under our Wealden area, is one of the many central ones, or the lateral one, immediately flanking the coal trough, is uncertain. Any attempt made to solve this great problem must be hailed with satisfaction; but it is not by one experiment, however, but rather by several, that the line of the great trough of productive coal measures will be determined."

These petitions to practical science, aided by capital and necessity, have at last partly helped to solve the long-discussed problem, and we now have four if not five well-determined sites within the London area where the Palæozoic rocks have been definitely touched. They are Tottenham Court Road, Ware, Turnford, Crossness, Kentish Town, and another distant but equally important trial at Burford, where the coal measures were satisfactorily proved.*

Old British Terrestrial Surfaces or Areas.

There seems to be good reason for believing that a once continuous north and south range of older Palæozoic land extended from the Polar regions to the Mediterranean. The only portion remaining entire is the Scandinavian peninsula, ranging through about 15° of latitude; it is known "beneath newer and overlying deposits of Northern Germany, the Vosgean and Schwarzwald ranges, and expands into the elevated plateau of Central France."

Mr. Godwin-Austen believes it to be traceable to the islands of Corsica and Sardinia, north of the African coast.

Westward of this another mass of old land occurred "to the north-west of the British Islands, and probably in its range formed the western boundary of the great European basin." The sources of these oldest sedimentary strata will ever remain a mystery; such are now either concealed beneath the Atlantic, through depression, or entirely removed through denudation. "The *materials* that supplied these oldest British strata have wholly disappeared," for doubtless the stratigraphical arrangements of these early deposits was in subordination to masses removed, and "the extent and dimensions of the Palæozoic masses afford an indication of how vast a region has disappeared." †

* See section from north to south (Sussex to Bedfordshire), across the London Basin (Reigate to Biggleswade), showing the places of the five trials by vertical lines, Pl. VII., sec. 2. The section is copied from Professor Prestwich's work on the water-bearing strata of the country round London.—Pop. Sci. Review, vol. xi. t. 75.

† Vide "Quarterly Journ. Geol. Soc." vol. xii. pp. 42 and 43. (Austen.)

Coal Measures beneath the South-East of England.

The predictions (for such at the time they appeared to be) of Mr. R. A. Godwin-Austen, so far back as 1856, as to the physical condition of the older rocks beneath the south-eastern part of England, and probable extension of the coal measures under the same area, seem now to be almost fulfilled; but as Mr. Austen then stated, "*any restoration of the European surface for this very early period must be purely ideal,*" it was to the correct restoration of definite boundaries for areas of land and water in the upper portions of the Palæozoic group that his views and speculations mainly looked for confirmation. Mr. Austen then stated that "those terrestrial masses which are represented *only* by the oldest Palæozoic groups had mostly disappeared;" nevertheless, he says, "we can ascertain something as to their mineral composition and the spaces they occupied, and in this way sketch out the surface of the northern hemisphere under its earliest arrangements."

Of late these far-seeing views and generalizations, and which at first sight seemed problematical, have been singularly realized and verified. Mr. Austen selected for his theme the intricate question of the "probable extension of the coal measures beneath the south-eastern part of England." By this he not only attempted to trace the terrestrial surface on which the old British coal forests stood, and their probable range and area, but carried his researches into western Europe, from Valenciennes to the valley of the Ruhr, east of the Ardennes, a distance of 170 miles, and then on to Westphalia. Along this great coalfield numerous trial-shafts have indicated its probable extension and continuity.

The Valenciennes coalfield is known to extend and has been proved 80 miles west of Valenciennes by Douay, Bethune, and St. Omer, and worked beneath the Chalk of the north of France.

The Palæozoic rocks of the Boulonnais have been revealed below the cretaceous series at Guines at a depth of 800 feet, and consisted of sandstones and shales; and as will be seen hereafter, the Silurian rocks below, of older date still, were touched by the boring-tool at the same depth at Calais, and at a depth of 1,100 feet, and below the chalk the true Coal-measures were determined.

The determination or recognition of the presence of the Coal-measures (Upper Palæozoic rocks) in the north coast of France, their undoubted connection with and prolongation from the Belgian area, led to the views then enunciated by Mr. Godwin-Austen as to the "amount of evidence (*à priori*) as to whether the coal series may be continued further west across the Straits of Dover and so beneath our south-eastern counties," and

"whether, if so, the coal measures were likely to occur under such condition of depth with respect to the overlying formation as would render them available to us."*

It was not the question of the Coal-measures only being present; on theoretical grounds any other still older sedimentary rocks down to the lowest Cambrian may occur—continuous, either as old land from northern or eastern Europe, or as an easterly prolongation or extension of our north and south Welsh Cambrian or Silurian rocks, rolling away beneath the central, eastern, and southern counties; the floor, indeed, on which stand unconformably all the newer or secondary and tertiary series in their varied features as we now see them.†

It must be borne in mind that in tracing out the physical outlines of western Europe during early times, or its early physiography, Mr. Austen included under the term Carboniferous those rocks, or conditions, whether terrestrial, fresh-water, or marine, from the Marwood and Pilton beds of the Upper Devonian to the top of the Coal-measures or the Upper Palæozoic group. His middle group comprised two series, being equivalent to the Upper Silurian and Devonian, and his Lower Palæozoic group embraced all the marine sedimentary strata up to the Lower Silurian inclusive; it is important to define the classification then used by Mr. Austen, and also in subsequent research and literature.

Mr. Godwin-Austen ‡ showed that the coal measures which thin away under the chalk near Thérouanne probably set in again near Calais, and are prolonged (beneath the Tertiary and Chalk strata) in the line of the Thames Valley parallel with the North Downs, and continue thence under the valley of the Kennet into or towards the Bath and Bristol coal area. On theoretical grounds, carefully thought out, he concluded that the Coal-measures of much of England, France, and Belgium were probably once continuous, and that the present coalfields were merely fragments of one great original deposit which he inferred had been broken up in two directions, but prior to the deposition of the now overlying secondary rocks. This line of disturbance trended generally in an east and west direction, and part of it formed the anticlinal of the Ardennes, by which the Belgian coalfield had been brought to the surface; and the Mendip Hills with the Somerset coalfield are also on that same

* "Quarterly Journ. Geolog. Soc." vol. xii. *loc. cit.*, and vide Plate VII. fig. 8 map showing the continuity and probable extension of the Belgian coal-measures under the Straits of Dover and the Wealden area, etc., and on to the Mendip Hills and South Wales. (Copied from Professor Prestwich's paper, Pop. Sci. Review, vol. xi.).

† Vide Section 4, pl. VII.

‡ "Quarterly Journ. Geol. Soc." vol. xii. 1875.

line of strike. The Belgian coal-field is but one of a deep, long and narrow series, ranging from Westphalia to the north of France. The most easterly is that of the Ruhr, the second Aix-la-Chapelle, the third Liége, and the fourth Hainault and Valenciennes; it is then probably hidden on its north-westerly strike from Thérouanne by the newer rocks, and its extension is proved by boring at Calais; the main axis (that of Ardennes) crossing the Straits of Dover, passing, as before stated, south of London through Berks, Wilts, and into Somersetshire, there to join the Mendip disturbances, and on to the southern edge of the great and exposed Welsh coalfield, by Worm's Head, Tenby, and St. David's, determining and probably defining the boundary between the Marine Devonians on the south of the Mendip and Ardennes axis, from that of the Old Red Sandstone north of it, and the great Hereford and Brecknock Old Red north-west of the Severn.* In 1872 Professor Prestwich wrote his most able paper in the "Popular Science Review" (*loc. cit.*), stating therein (p. 235) that "between Clan Down, near Bath, and the Well, at Kentish Town, no trial for coal or water had been carried to the base of the secondary rocks or had reached more than about 600 feet beneath the sea level." Since then, not many miles north of the latitude of Bath, the boring at Burford, in Oxfordshire, has passed through the lower secondary rocks and into the Coal-measures, touching them beneath the New Red Sandstone at 1,184 feet. "There can, however," says the learned author, "be little doubt of the continuity of the range of the Palæozoic rocks under these newer formations from Belgium to Somerset; but whether or not the coal measures were ever continuous between the two districts, and whether, if they were, they have been removed by denudation, *leaving only the Lower Palæozoic rocks*, requires further discussion."

Again, Mr. Prestwich, with far-seeing induction (as subsequent investigation has proved in Oxfordshire), discusses the question of the extension of the Bristol coalfield eastwards. This independent basin is cut off both on the east and on the west by ridges of Millstone Grit and Mountain Limestone—the general belief being that the eastern boundary limits the extension; or that eastward of the north and south strike of the edge of the basin there are no more Coal-measures. This eastern edge is covered by the secondary rocks (Trias, Lias, and Oolite), thus causing much uncertainty as to the disposition (or arrangement) of Palæozoic rocks under or east of them.

"Admitting," says Mr. Prestwich, "the basin to be complete and isolated, that is no proof that the older Palæozoic rocks prevail exclusively or come to an end on the east side, for the

* Vide sketch-map No. 8, plate VII.

coal measures of the Somerset basin maintain their full development to the edge of the basin and are then *cut off by denudation* and not brought to an end by thinning out. They form part of a more extended mass of which we have more than one fragment, while on the west another portion exists in the Welsh basin, and another in the newly-discovered small basin of the Severn Valley, *and there is no reason why on the east the same* disposition should *not prevail.*" * These far-seeing views as to the probable physical history of the extended deeply-seated area between Bath and Frome and the German Ocean are being slowly, but I believe surely, verified, and bear entirely upon the researches now being carried on, and upon the palæogeographical distribution of rocks and life over an immense underground tract, and which here and there, by means of the boring-rod, are being tested, and those theoretical views of Mr. Godwin-Austen and Professor Prestwich confirmed.

Although, however, at present no true Coal-measures have been touched or proved along the valley of the Thames, or their extension known to take place from Thérouanne, still the above views, although speculative, have the same value as when first propounded; for although the Devonian rocks have been proved at Tottenham Court Road, and Turnford, six miles south of Ware, it in no way invalidates or does away with the possibility that south of that area or even west of London the Coal-measures may occur. The failure of the sub-Wealden exploration, intended to prove the presence of these older rocks below the Wealden area, leaves the question still open as to the correctness of the views propounded by Mr. Austen with relation to the extension of the Boulonnais and other rocks. Speaking of the axis of Artois, Mr. Austen says,† "that it is continued across our area by the range of the North Downs, and those of Hants, and that on the north limit of this ridge the beds dip suddenly and rapidly; hence a line of fractures extending from near Arras to the east end of the Boulonnais and from the north-west point of the Wealden denudation to the Valley of Devizes." This relative depression on the north has preserved the Nummulitic series (Lower Tertiary), just as along the Franco-Belgian line the depression was the cause of the preservation of the great coal trough. Applying this consideration to the structure of our area, from Kent into Somerset, we may feel sure that a like arrangement of the older strata was from the Valley of the Thames into the Kennet; *along this line the coal measures may be reasonably supposed to have been preserved.*‡

* Vide POPULAR SCIENCE REVIEW, vol. xi. p. 237–240. 1872.

† "Quarterly Journ. Geolog. Soc." vol. xii. p. 62.

‡ Vide pl. VII., fig. 8.

Should the Somersetshire coalfield be repeated to the east, which is by no means improbable, we should then expect to find that extension under the great plain of Salisbury and the Kennet Valley, by Hungerford and Newbury, thus meeting the Belgian prolongation from the east 25 miles due north of Marlborough. The Burford trial has proved an extension of either the Forest of Dean or the Bristol coalfield, or both, at (as before stated) 1,184 feet in depth; and it is 35 miles east of the two coalfields named, and thus much nearer the areas predicted by Mr. Godwin-Austen.

Professor Prestwich, in evidence before the Royal Commission,* favoured the view of this easterly extension from the present boundary of the Bristol coalfield, and knew no reason why a coalfield may not be entirely covered up east of Bath, or Radstock, &c. Again we refer to the Burford boring as tending to confirm Professor Prestwich's views.

The axis of Artois, which plays so important a part in the physical structure of the region through which it passes is traceable from the Mendip Hills to the old county of Artois in France; and the singular unconformable relation of the Oolitic beds of Frome, &c., to the Carboniferous masses of the Mendip and its anticlinal, are the same as those of the Oolites of the Boulonnais. We now partly know what thickness the Jurassic rocks attain below the Wealden beds, in the Wealden area, where 1,990 feet have been passed through, 800 of which were Portland, Kimmeridge, and Oxford clay. So that the mooted point in Mr. Austen's paper (*loc. cit.*), to what extent the Oolitic group may exist below the Wealden and Cretaceous groups of Kent, Sussex, and Surrey, has been partly set at rest, but not decided either as to complete sequence, presence, or thickness, for nothing below the Oxford clay is yet known, and therefore the Palæozoic rocks or their age can only be inferred.

Sub-Wealden Area and its Exploration.

In April 1872, at the meeting of the British Association at Brighton, it was arranged that a trial should be made in the Wealden area, for the purpose of testing the presence of and depth to the Palæozoic rocks beneath the secondary strata of the Wealden. This undertaking had a twofold bearing; the first being, as before stated, to test the thickness of the overlying secondary rocks, and the age of those older series that may be beneath them. The second had special reference to the solution of the problem propounded by Mr. R. Godwin-Austen, relative to the existence and extension of the coal measures or

* Report of the Commissioners appointed to inquire into the several matters relating to coal in the United Kingdom. Minutes of Evidence, pp. 146–418.

other Palæozoic rocks ranging from the Belgian and north French areas towards or under the south-east of England. A spot at Archer's Wood, Netherfield, near Battle,* was selected to determine this, by means of the diamond boring process, and no less than 1,998 feet were passed through, ending in the Oxford Clay at that depth. The Purbeck and Portland beds were but thinly represented in the boring; but the Kimmeridge Clay, of unprecedented thickness, equalled nearly 900 feet, or three times its normal thickness; this doubtless was owing to the depression of the Wealden area during the deposition of the Kimmeridge Clay, its accumulation being equal, *pro ratâ*, to subsidence. From top to bottom of this formation it was richly fossiliferous, every core yielding the characteristic Kimmeridge fossils. The Coral Rag was passed through, and the bottom of the boring-rod, with its diamond crown, was forced to yield to circumstances and end in the Oxford Clay. The first and only attempt to solve an important problem, purely for scientific purposes, was thus abandoned owing to the smallness of the core, and we still remain in ignorance and doubt as to the nature and depth of the older rocks in the south-east of England. The name of Willett will ever be honourably associated with this memorable undertaking, for at his suggestion and through his laborious efforts and labours, and under his guidance, it was commenced and continued; the ending and stoppage being due to want of machine power to penetrate deeper, and the too rapid decrease in the diameter of the cores. Subsequent boring, however, in search of water in the heart of London, at 1,140 feet revealed the Upper Devonian rocks, thus clearly showing that the expected and sought-for Palæozoic rocks should be, and doubtless are, under the Wealden area, but whether Coal Measures, Carboniferous Limestone, Devonian or Silurian, we have yet to learn. In Calais the Coal Measures were touched at 1,032 feet; Kentish Town, red rocks below the Gault at 1,114 feet; Devonian, in Tottenham Court Road, at 1,140 feet; at Crossness, red sandstone at 1,056 feet; thus showing that a broadly spread floor of Palæozoic or most ancient rocks is spread under the extensive region of the south-east of England.

To show still more conclusively the extension and easterly spread of the older rocks from the westward, we cannot pass over the important boring at Bradwell, near Burford, in Oxfordshire, where at the depth of 1,184 feet the Coal Measures were determined, several species of characteristic coal plants being brought up in the cores. Whether we are to look for a southern prolongation of the Warwickshire or South Staffordshire coalfield, or whether it is the setting in of another extensive coal-

* Vide pl. vii. sections 1 and 3.

field east of the Forest of Dean or Bristol basin is a question; it adds greatly, however, to the extension of the Palæozoic rocks towards the London basin, and enriches our knowledge as to the palæogeography and physiography of the coal tracts probably hidden under the Jurassic and Cretaceous rocks of Oxfordshire, and possibly of Berkshire and Middlesex. All the lower Secondary rocks were passed through in the Burford boring, but evidently attenuated on the line of dip.*

Other borings, exactly on the same latitude, 80 miles to the eastward, and at less depth, reveal or shadow forth what is the nature of the physical geography and geology between the two points; hidden as it is, its subterranean features can be broadly sketched. The outlines of this palæogeographical problem have been almost prophetically dealt with both by Mr. Godwin-Austen and Professor Prestwich, and there can be little doubt that owing to the absence of all the lower Secondary formations, the Tertiary and Cretaceous rocks in the London basin repose directly upon a floor of older Palæozoic rocks; such has long been the view held by these two distinguished physicists. We have now only to define the area and nature of that floor, the age of the rocks composing it, and its relation to the old rocks of western England or of western Europe.

Ware, Hertfordshire, and the older Rocks.

Being desirous to increase their store of pure water, the New River Company (through the Diamond Boring Company) put down a trial boring near Ware, commencing their operations in Chalk, and immediately north of the outcrop of the London Clay, which so well defines the district. Less perhaps was known of this immediate area than any within a radius of 50 miles from London, so far as underground geology is concerned.

The central position of Ware, with respect to the supposed conformation and structure of the basin rendering it probable that the two Greensands below the Chalk, or one of them, would yield a very large supply of pure water, operations were carried on through the Chalk, Upper Greensand, and Gault, by the Diamond process, and cores brought up over 1 foot in diameter to the depth of 800 feet. The Chalk and overlying gravel measure 558 feet, the Upper Greensand 77 feet, and the Gault 160 feet, all perfectly horizontal, and the Lower Greensand was unmistakably represented by a thin stratum of the 'Car Stone' much washed away through the operation of boring. This rather

* Lower Oolite, 148 ft.; Lias, 598 ft.; Rhætic, 10 ft.; New Red Sandstone, 418; Coal measures, 325 ft., passed into.

coarse-grained loose bed of sandstone underlay the Gault, and rested immediately and most unexpectedly upon the old and highly-inclined Palæozoic rocks—a Silurian floor of the Wenlock age, dipping at an angle of 40°, but to what point of the compass at present we do not know, although probably to the south.

Not long since (June 1877) it was our good fortune to announce the discovery of the Upper Devonian rocks, under Tottenham Court Road, at Messrs. Meux & Co.'s Brewery, at the greater depth of 1,140 feet. They were penetrated 70 feet. This new feature in the palæogeography of the eastern counties, anticipated in some form by Austen, Prestwich, and Hull, is now verified, and the age of the rocks determined.

It will be asked by those who give attention to stratigraphical geology, whether these Silurian rocks are of the British or Continental type; in other words, are they or can they be correlated with our Welsh or English Wenlocks, or are they of the Ardennes type? Do they constitute a portion of the Dudley or Wenlock rocks of Wenlock spreading away eastwards, or are they a prolongation of the Silurian rocks of Belgium—the western edge or extension of which reaches beyond the longitude of Greenwich? In other words, were these two separate basins, or one? Is it an extension from the West of Europe, or an easterly expansion of the Upper Silurians of the Silurian area?

The facies of the fossils and the character of the rock in all its essentials are decidedly British, and it cannot be doubted that they are a continuous and denuded surface of the same rocks now conspicuously exposed in the picturesque scenery of the hills of Herefordshire and Worcestershire. The thirty species of fossils noticed in the cores are, species for species, identical with those of the Wenlock Edge, or Wren's Nest, near Dudley, and no difference can be detected in the lithological characters of the rocks.

In direct line or latitudinally the Wenlock rocks of the Malvern, Woolhope and May Hill may claim connection, but we regard the Ware fossils and rock as having more affinity with the Wenlock Edge series, or that group which borders and underlies the western side of the great mass of the Old Red Sandstone of the north-west part of Herefordshire, although distant nearly 160 miles. Could we remove the overlying Mesozoic series between Ware and Burford, in Oxfordshire, and again expose the Coal Measures known to occur there at the depth of 1,184 feet, then should we understand the thinning away of the Jurassic and lower Cretaceous series eastwards towards this Silurian ridge, and what we should probably call the Oxfordshire and Hertfordshire coal basins would be exposed and correlated, for we can hardly now doubt this extension of the known Burford Coal Measures, in all probability, however,

terminating westwards of Ware against the Silurian series, the physical geography aspect of which at the time of the coal growth must have been much the same as the present, could the 80 miles area be re-elevated from 800 to 1,000 feet.

Another boring is being carried down by the New River Company at Turnford or Wormley, six miles south of Ware, the revelations from which are more than anxiously looked for. This piece of engineering skill it is intended to complete as far as passing through the Lower Greensand. The Turnford boring is now 980 feet deep, and still in the Gault; it is therefore 200 feet lower than the bottom of the Ware rocks. This increased depth is owing to a depression, or perhaps valley, in the Palæozoic land below, which seems more than probable, when we know that the same thickness of Gault occurs over the northern area generally. It is 160 feet thick at Ware, Turnford, Loughton, Kentish Town, and Tottenham Court Road; at Crossness, 140 feet. In most cases, when bored through, this Gault has a floor composed of Palæozoic rocks; at Kentish Town a red micaceous sandstone; at Tottenham Court Road the Lower Greensand rests upon a true Upper Devonian; at Ware on the Wenlock rocks of the Upper Silurian, and at Crossness on red sandstone (age ?). We are thus justified in stating that the space between Messrs. Meux's, at Tottenham Court Road, and Ware—a distance of 24 miles—is occupied by the Upper Silurian, and probably the Lower, Middle, and Upper Devonian rocks, which may be rolled and folded on their dip. To what distance rocks of older date may occur north of Ware, further experiment only will decide. Harwich—which lies ten miles further north, and probably on the strike—has revealed them at a depth of over 1,000 feet.

Few, perhaps, are aware of the difference that exists in the thickness of rocks of the same age in different, yet not very remote localities. In Britain the Cambrian and Lower Silurian deposits are from 20,000 to 30,000 feet in thickness; whilst in Sweden and Russia the deposits which are the equivalents and representatives of these epochs rarely, if ever, exceed 1,000 feet. This difference is due to the form and nature of the pre-Cambrian land on which the newer series, Cambrian and Silurian, are placed; for there cannot be any doubt that such pre-Cambrian land did exist, and extended over the present known European area, with probably a great expansion westwards of the British Islands and the Spanish coast. The old plateau before-named is part of this extension. I believe also that the crystalline rocks of Scandinavia to the north constituted a part of this pre-Cambrian stage, and also parts of North Wales, and the north-west of Ireland. The Hebrides and St. David's are remnants of this epoch of the highest antiquity. This old land must have been slowly submerged and denuded to receive the so-called

Cambrian and Lower Silurian rocks, those which are now known by the name of the Longmynd and Harlech, with the succeeding Lingula Flags, Tremadoc and Arenig, life groups of antiquity so high that we have no formula to express their age.

We have no evidence yet as to these rocks of highest antiquity occurring eastwards of the Pennine axis, of which Charnwood is a prolongation; and longitude 1°50′ W. limits the easterly surface exposure of the lowest Palæozoic rocks, and these are the Charnwood slates, &c., of yet undetermined age. The problem still remains unsolved; but the Ware trial has revealed a group of rocks at a depth of 800 feet that shadows forth older rocks still, and should the dip of these Hertfordshire Silurians prove to lie to the south, we may anticipate the more ancient series further north towards Cambridge. Be it remembered that the strike from Ware in that case would be directly towards Harwich. The four trials are from London due north. At two of these (Ware and Turnford) the true direction of the dip will, it is hoped, be tested and determined, the solution of which is worthy of all experiment and patience. If successful, it will be the key by which the hidden structure and wealth of any given area in Britain may be tested.

What are the Old Rocks South of the Thames?

Since the determination of the presence of the Devonian rocks at Tottenham Court Road, north of the Thames, and the Upper Silurian at Ware, 24 miles further north, our views relative to the distribution of the Coal Measures have materially altered. It would now appear from recent research, that there is little chance of any rocks younger than the Devonian occurring due north of London, beyond latitude 52° 30′ N., or east of longitude 1° W. Whatever may be the contour or disposition of the old Devonian and Silurian land at from 800 to 1,000 feet deep it is clear that all the stratified rocks between the Devonian and the Gault are wanting; in other words, the whole of the Carboniferous series, the Permian and Triassic, the Jurassic including the Lias, and the Purbeck and Wealden are wanting or missing north of the Thames to the latitude above-named. This shows the great unconformable overlap upon the Silurian and Devonian floor, which became submerged to receive the upper Secondary rocks whose outcrop now extends throughout the length of England, from Redcar in the north-east to Teignmouth in the south-west, and which also fill the great depression which extends from the Mersey and the Dee to Burford in Oxfordshire, where it is 756 feet deep, as proved by the boring. How much further east it may extend we know not, but little west of London it seems to

have thinned away, as do most of the Secondary rocks, probably against the Palæozoic plateau.

The key to the underground Palæozoic geology of the country south of the Thames, *had it been completed*, must have been the sub-Wealden boring. Unfortunately for science, the problem was never solved, the nearly 2,000 feet of Secondary strata passed through being all above the desired or anticipated ancient land. The fact that the Upper Devonian rocks were under the heart of London, and the Silurian some miles north of that, induces us to believe that we must look to the south of London, as pointed out by Mr. Godwin-Austen, as the area where we should expect to find the Coal Measures, ranging probably under or north of the North Downs. Their southern extension, until revealed through necessity or enterprise, will remain unknown, but we doubt not their presence.

Palæontology of the Upper Silurian and Devonian Rocks north of London.

The extensive area north of London occupied by the Tertiary strata as far as Ware, with the Chalk beneath, is now known to be underlain by other rocks of high antiquity, now determined to be, through organic remains, the Upper Silurian, and closely resembling, if not identical with, the Wenlock group of the Wren's Nest, near Dudley, or even the more distant groups of the Wenlock Edge or the Ludlow Promontory. The facies of the fossil contents of the Upper Silurian cores at Ware is not that of the Malvern or Woolhope series, or of the still nearer beds at Tortworth, although nearly in the same latitude; nor can they be correlated with the Upper Silurian series of the Ardennes in Belgium, from which they essentially differ. There can be no doubt of their affinity with the true Silurian rocks to the west of the Severn Valley, or the Dudley group, thus incontestably proving the easterly continuity and extension of the latter. So rich in fossils are these Ware Silurians, that no less than thirty-three species have been obtained; every portion teems with extinct life, especially Brachiopoda, twenty-one of the thirty-three species belonging to this group. The characteristic trilobite *Phacops caudatus* with *Ischadites Kœnigii*, Crinoidea, and Orthoceratites, are sufficient data in themselves to establish both the age and affinity of the fossils, which now are known to occur on this floor 800 feet deep, on which rest the Cretaceous and Tertiary series of Hertfordshire. The following list will show the rich fauna of the Wenlock Rocks below Ware. All the fossils were obtained from a core less than three feet in length and one foot in diameter.

I. Protozoa	1. *Ischadites Kœnigii*, Murch.
II. Echinodermata	2. *Taxocrinus*, sp.
	3. *Periechocrinus moniliformis*, Mill
III. Annelida	4. *Tentaculites ornatus*, Sby.
IV. Crustacea	5. *Phacops caudatus* Brünn.
V. Mollusca-Brachiopoda	6. *Orthis canaliculata*, Dalm.
	7. ——— *elegantula*, Dalm.
	8. *Meristella tumida*, Dalm.
	9. *Cyrtia exporrecta*, Wahl.
	10. *Spirifera elevata*, Dalm.
	11. ——— *plicatella*, Linn.
	12. *Athyris*, sp.
	13. *Crania implicata*, Sby.
	14. *Rhynchonella cuneata*, Dalm. ? or *deflexa*, Sby.
	15. *Atrypa reticularis*, Linn.
	16. *Pentamerus galeatus*, Dalm.
	17. ——— *linguifer*, Sow.
	18. *Strophomena euglypha*, Dalm.
	19. ——— *reticulata*, McCoy.
	20. ——— *depressa*, Dalm.
	21. ——— *rhomboidalis*, Wahl.
	22. ——— *antiquata*, Sby.
	23. *Chonetes*, sp.
	24. *Leptæna sericea*, Sby.
	25. ——— *transversalis*, Dalm.
" Conchifera	26. *Pterinea*, sp.
	27. *Mytilus mytilimeris*, Conr.
	28. *Ctenodonta*, sp.
	29. *Orthonota rigida*, Sby.
" Gasteropoda	30. *Euomphalus rugosus*, Sby.
" Cephalopoda	31. *Orthoceras attenuatum*, Sby.
	32. ——— sp.
	33. ——— *angulatum*, Wahl.

It may be asked what has become of some 20,000 feet of strata ranging from the Neocomian down to the top of the Upper Devonians, all the Coal Measures, Triassic, Jurassic, and Wealden series, being absent between Ware and London. No greater unconformity is known in the British Islands, or was suspected here until the boring for water by the New River Company revealed these grey argillaceous Silurian shales and fossils, dipping probably to the south, at an angle of 40°. The Jurassic Rocks must have thinned away west of Ware, Turnford, and London, against yet resting upon this unseen and hitherto unknown Silurian range. Whether all the should-be superincumbent strata named were ever present, and subsequently denuded, during elevation, we know not; but the presence of the Upper Devonian strata at Turnford, with their characteristic fauna, and at a lower geographical level, tends to show considerable movement.

At Turnford and at Tottenham Court Road the red fissile shales contain the same fossils—*Spirifera disjuncta*, *Pterinea*, and *Rhynchonella*, &c., being common to both places, thus

showing that the Devonian rocks occupy this area 1,000 feet below the surface through a known extension northward from London, of twenty-four miles.

The exposed Devonian Rocks of North Devon, on the one hand, and the Silurian Rocks of Wales on the other, are now proved, through their fossil contents, to be continuous to and to extend under the London Basin, striking below the German Ocean on to Belgium and Germany, holding, so to speak, on their denuded surfaces much of, if not all, the superincumbent strata of the south and south-eastern part of England; had the sub-Wealden boring touched the Palæozoic rocks at Battle, nothing more would have been desired to show the palæogeographical structure of the south-east corner of Britain and our relation to north France and Belgium.

REVIEWS.

ELECTRICITY.*

NO branch of experimental science has passed more decidedly from its first or inductive stage into its second or computative, during the last thirteen years, than that of Electricity. Many who studied it lovingly and with appreciation at the former period will admit with willingness their obligations to the original Text-book of Dr. Noad, as well as to the bulkier Manual by the same author which preceded it. It was at the time singularly complete and exhaustive. In the preface, dated from the School of St. George's Hospital, in September 1868, its precise position in the chronology of physics is accurately dated, by the cordial acknowledgment accorded to that "beautiful electrical instrument invented by Professor William Thomson, F.R.S., namely, his Portable Electrometer," and by the prefatory note on the recovery of the first, and the successful laying of the second, Atlantic Cable. The preface reappears in Mr. Preece's revised edition in contrast with the editor's Introduction. In this he evidently, to a certain extent, grasps the progress since then. "All sciences," he says, "in their earlier stages excite the imaginary powers of the mind" (a phrase which is probably intended to mean the imagination), "but in their later stages the calculating powers. The study of Electricity has been a fine sphere for hypothesis; but it has now become a cultivated field for the exercise of the quantitative tendency of the mind;"—an obscure sentence which probably shadows forth the idea that from hypothetical, Electricity has, by increased mental cultivation, become computational. In the same rather hazy, jaunty, and unsatisfactory prologue, which occupies very little more than four pages, we are told that recent discoveries "have rendered it an exact science," and that, notwithstanding this fact, "theory has been as much as possible excluded; first, because there really exists no theory of Electricity properly so called; and secondly, because what theory there is is used more for illustration than for explanation;" statements which appear to be somewhat self-contradictory.

A feeling of disappointment thus instinctively produced at the outset does

* "The Student's Text-book of Electricity." By Henry M. Noad, F.R.S., &c. A new edition, carefully revised, with an Introduction and additional chapters, by W. H. Preece, M.I.C.E., &c. Crown 8vo. pp. 615. London: Crosby Lockwood & Co., 1879.

not diminish on going more deeply into the revised edition. All the early chapters seem to be very little altered from what was presumably up to date in 1866, but which is slightly antiquated now. To the end of the fourteenth chapter on Diamagnetism, there has been so little change that page 291 of the new edition corresponds with page 283 of the original work. The whole of this chapter, with the exception of the pagination, is evidently printed from the old plates, no notice being taken of the rotation of the plane of polarization from the polished pole of an electro-magnet, nor of that recently established to be experimentally determinable in air and gases. The fifteenth, sixteenth, seventeenth, and eighteenth chapters appear to have received addition amounting to only 68 pages in 485. Short chapters have been introduced on Duplex and Quadruplex Telegraphy, the Telephone and Microphone, and the Electric Light, which raise the size of the new volume 92 pages in all over its elder brother of 1866. The result is patchy and unsatisfactory; partly because the new and the old cohere badly; but more because the totally changed point of view in which the whole subject is now regarded, and which is acknowledged in the preface, fails to be realized in the body of the work. It would be ungracious to point out specific errors, of which there are many. One instance, however, which occurred to the writer may be noted. He turned immediately to the article "Condenser," for fresh information on the great development which this apparatus has of late years received, hoping to obtain practical hints for the use of mica, paraffin, and other dielectrics. There is not a syllable on the subject, beyond what was in the original edition.—W. H. Stone.

ORGANIC CHEMISTRY.*

THE reader will be disappointed if he expects to find in this little volume a good general outline of Organic Chemistry. The contents remind one of a student's note-book in the way statements are crowded together, unaccompanied by sufficient explanations, and not unfrequently damaged by inaccuracies. For instance, ethyl diamine stands for ethylene diamine (p. 16); trimetho-dichloride for trimethyl-arsine dichloride (p. 25); ethylene dichloride for dichloride.

We are told that "methyl alcohol is an inflammable colourless liquid, having an odour somewhat like ordinary alcohol, and a burning taste." "It is generally used as a substitute for ordinary alcohol on account of its cheapness, and these two are mixed and sold as methylated spirit" (p. 47).

Pyrogallic acid is said to have the composition C_6H_5O (CO.HO) instead of $C_6H_3\left\{\begin{matrix}OH\\OH\\OH\end{matrix}\right.$—an important difference (p. 127).

About 170 pages are devoted to this part of the book; the remaining portion being answers to questions from the Examination Papers of the Science and Art Department.

* "A Manual of Organic Chemistry." By Hugh Clements. Sm. 8vo. London: Blackie & Son, 1879.

THE GAULT.*

MR. PRICE has conferred a boon on the student of Cretaceous geology by the publication of his work on the Gault, the result of some years' special study of that formation. It comprises a succinct account of the geographical distribution, lithological characters and fossil contents of this, the chief argillaceous member of the Cretaceous system; from which we learn that the sea, in which this deposit was formed, must have occupied an extensive area in what is now part of south-east England and part of the Continent, so that its waters on the west washed the Triassic and Jurassic cliffs of the midland counties, and to the east its waves beat against the northern sides of the Hercynian mountains.

From the varying mineral character of these old coast lines, the nature of the deposit, although mostly argillaceous, must have slightly differed according to locality, as described by the author, while the now imbedded fauna would differ somewhat in character according to depth, and hence probably the number of zones described by Mr. Price, as well shown in the sections at Folkestone and elsewhere.

Chapters are devoted to the geographical range of the formation, and a valuable table of 800 species of fossils arranged under twenty localities, occupies about half the work, which also contains a full bibliography and comparative tables of strata, so that the entire work forms a useful handbook, as intended by the author, of the Gault formation.

CAMBRIDGESHIRE GEOLOGY.†

THE Sedgwick Prize was established for the purpose of rewarding the writer of the best essay on some subject of Geology, and is given every third year. The competition is, however, restricted to graduates of Cambridge under certain restrictions. The last essay for 1873 treated of the Potton and Wicken phosphatic deposits, and the subject proposed for 1876 was "The Post-Tertiary Deposits of Cambridgeshire." The Prize was awarded to Mr. Jukes-Browne; but circumstances prevented the publication of his memoir until the autumn of last year, and our notice has been unfortunately delayed. The various drift and superficial deposits of the county have engaged the attention of geological writers since the beginning of this century; but the object of the present essay is to add more facts to the stock of information on these points, and to present as complete an account as possible of the accumulations met with in the Cambridgeshire district.

After giving a general account of the literature of the subject, the author treats of the physical features of the county, of the glacial deposits, followed by a description of the hill gravels, the valley gravels of the early and present

* "The Gault:" being the substance of a Lecture delivered in the Woodwardian Museum, Cambridge, 1878, &c. By F. G. H. Price, F.G.S. 8vo. London: Taylor and Francis, 1879.

† "The Post-Tertiary Deposits of Cambridgeshire:" being the Sedgwick Prize Essay for 1876. By A. J. Jukes-Browne, B.A., F.G.S. 8vo. Cambridge: Deighton, Bell & Co.; London: G. Bell & Sons, 1878.

river systems, and the correlation of the Cambridgeshire drifts with those of the eastern counties.

In conclusion Mr. Jukes-Browne offers a few remarks on the conditions under which the glacial deposits have been formed, and the age of the principal features of the country—questions which have been much contested, and certain opinions connected with which he briefly criticizes, and explains his own views upon them.

Without, however, attempting to give a history of the manner in which Cambridgeshire was moulded, the author gives his views as to the relative age of its principal physical features from the evidence he has brought forward, and states that "the whole succession of post-glacial valley gravels seems indeed to have been singularly well preserved in this part of England, and if the various beds could be thoroughly disentangled, they would mark out the courses of the streams at different times, and present us with a picture of the successive changes which have taken place in the river system from the glacial period to the present time."

To the student of Post-Tertiary Geology this will be an acceptable essay, as the descriptions are given in a clear and systematic manner, embodying not only the author's own researches, but those of other geologists who have specially studied these deposits.

THE ELECTRIC LIGHT.*

THIS is an enlarged issue of the pamphlet by Mr. Shoolbred, already noticed in the two articles upon the Electric Light in our numbers for January and April. It contains a fair description of the various dynamo-electric machines lately invented; and, although Mr. Chapman's gravity lamp, which by many years preceded similar recent contrivances, and quite equalled them in performance at the recent exhibition in the Albert Hall, is still excluded, those now before the public are illustrated and explained. The plates are on a good scale, and easy to understand. Mr. Shoolbred is evidently a thorough and uncompromising advocate of this mode of illumination; so that any adverse facts or opinions must be sought for elsewhere.

THE HEAVENS.†

"Spake full well, in language quaint and olden,
One who dwelleth by the castled Rhine;
When he called the flowers so blue and golden,
Stars, that in Earth's firmament do shine."

MR. PROCTOR might well have added the above verses of Longfellow to the stanza of Shelley which adorns his prefatory page. They would complete the simile which evidently underlies his quaint and fanciful title.

* "Electric Lighting and its Practical Application, with Results from Existing Examples." By J. N. Shoolbred, B.A., &c. 8vo. London: Hardwicke & Bogue, 1879.

† "The Flowers of the Sky." By R. A. Proctor, &c., &c. With fifty-four Illustrations. 8vo. London: Strahan & Co., 1879

Indeed, through nearly all the superscriptions of his works, there runs this pleasant archaic flavour, reminding the reader of an old library, of George Herbert, and Sir Thomas Browne. Nor is the tone of their contents dissimilar to the promise of the title-page. Although dealing with subjects exceptionally "dry," Mr. Proctor is what, for want of a better antithesis, we cannot refrain from calling, the most succulent of expositors. To men of formal, rigid, and "tetragonal" minds, this is perhaps a fault, a detraction from the sternness and severity of science. Contradicting the stoic exclusiveness of *οὐδεὶς ἀγεομέτρητος εἴσατο*, he says, Come hither, ye unlearned, while I discourse in simple and untechnical language of light, and space, of the infinitely minute, of the mystery of gravity, of the end of many worlds. Such, indeed, are the headings of his first five chapters. Nor are those which follow on the Aurora, lunar halos, moonlight, the planets, Mars, Jupiter, and the "winged Saturn," or on "fancied figures among the stars," treated with less of his usual fluency and discursiveness. The last chapter is on "transits of Venus." Here we must confess to a slight reminiscence of Mr. Dick, in the true history of David Copperfield, "who had been for ten years endeavouring to keep Charles the First out of the Memorial." But on this occasion we are only very gently reminded of the great controversy between Halley's and Delisle's methods of observing those important phenomena. As before, so now, we hold the opinion that these books are useful, and appeal to a class of readers who stand in awe of sines, cosines, and co-efficients.

W. H. STONE.

FIELD GEOLOGY.*

THE substance of this book, originally given as two lectures upon geological maps and instruments of surveying, in connection with the Scientific Loan Collection, has been considerably enlarged and revised, so as to form a new and independent work.

The long experience of Professor Geikie as a field geologist and Director of the Survey will fully qualify him to supply the wants of a large body of readers, who, having a general and even extensive knowledge of geology, find themselves to a great extent helpless when they try to interpret the facts they meet with in the field. Field geology is broadly distinguished from the researches which may be carried on in the library or the laboratory, and hence the object of the author has been to describe the methods by which the geologist may obtain his information regarding the nature, position, arrangement, and structure of a country. The subjects are arranged under two divisions—outdoor and indoor work, the former occupying by far the larger portion.

In the series of chapters composing the first part, which is well illustrated, the author describes the nature of field work, the necessary accoutrements, geological and other maps, the essential characters and origin of rocks, the nature and use of fossils, the unravelling of geological structure as connected

* "Outlines of Field Geology." By A. Geikie, LL.D., F.R.S. Second Edition. Sm. 8vo. London: Macmillan & Co., 1879.

with dip, strike, and faulting of rocks, and their curvatures, contortions, and cleavage, the nature of igneous and metamorphic rocks and mineral veins, with a chapter on surface geology as connected with physical features.

The second part treats of the nature of indoor work, as drawing geological sections, hints for the determination of minerals and rocks, and the method of preparing sections for investigation by the microscope. The drawing of geological sections is of much importance, considering how frequently false ideas are given by diagrammatic representations of the external form of the ground, thus tending to perpetuate erroneous notions with regard to the physiography of the land as shown by such distorted sections, sometimes almost grotesque in their exaggeration of natural forms. Similar erroneous notions apply to some drawings of unconformable stratification. We can corroborate Professor Geikie in his remarks on this structure, having recently seen drawings of much more impossible unconformities than even that given by him at page 113.

We may notice among the few typographical errors the letters *a c* of the woodcut, fig. 29, which are wrongly described, indicating an inversion of the strata, which is not the case, as shown by reference to the original figure (174), from which it is taken in the "Geological Observer." At p. 109 is described a ready means of estimating the thickness of strata, which appears more simple than that proposed by Professor Chapman. In this paragraph the author might have usefully alluded to the method of calculating the depth from the surface at which an inclined stratum might be reached at a given distance from the nearest outcrop.

To the geological student who is acquainted merely with the principles of the science derived only from book-study, this concisely arranged and pleasantly-written text-book by Professor Geikie, for guidance in the field, will be a valuable aid, as pointing out how and what to observe and how to record, thus adding fresh interest to his studies, and ministering to his further elevation and enjoyment, by a more practical knowledge of the nature of the district in which he finds himself situated, or into which the pursuit may lead him.

FRAGMENTS OF SCIENCE.*

WE need do little more than announce the publication of a new and enlarged edition of Professor Tyndall's "Fragments of Science." Deservedly recognized as one of our most brilliant writers on subjects connected with physical science, Professor Tyndall has the art of investing with a peculiar charm matters which at first sight might seem rather unpromising, while at the same time he is a most lucid popular expositor of scientific facts and theories. These circumstances make it no matter of wonder that the collection of essays, reviews, lectures, and addresses which he brought out a few years ago under the above title should have already arrived at a sixth edition. Of course, there are portions of these articles at

* "Fragments of Science." A Series of Detached Essays, Addresses, and Reviews. By John Tyndall, F.R.S. Sixth edition. 2 vols. Crown 8vo. London: Longmans & Co., 1879.

which even scientific men may cavil; and there are others, and indeed whole essays, which are regarded by certain unscientific readers as utter abominations, such as the discourses upon prayer and miracles, and the celebrated Belfast address; but the dispassionate reader, if any such can be found, will discover that there is a good deal of truth in them, and that the views they open up are at all events worth consideration. The present edition contains several new articles, among which the most important seem to be those on Fermentation and Spontaneous Generation, and the reply to Professor Virchow's commination of the Evolutionists. The author's lecture on the Electric Light is also included. As these and other additions have caused a considerable increase of bulk, the book is now divided into two volumes.

THE SEA-SHORE.*

TO the naturalist the sea-shore is so prolific of objects of interest, and the sea-side visitor is so often in want of something to interest him, that the constant crop of popular books describing, in more or less detail, the natural history of the sea need not excite much surprise. People can't be always walking up and down the pier or the parade, or listening to indifferent brass bands; and if the majority of those who try the natural history line don't make much of it, their efforts, at any rate, can do them no harm. Hence we are inclined to welcome every fresh addition to the popular literature of the shore, and we do this with particular satisfaction when the new-comer is the production of a good naturalist, and worthy of its parentage.

The latest accession to littoral literature, if we may use such an expression, forms one of a series of small volumes published by the Society for Promoting Christian Knowledge, under the general title of "Natural History Rambles," and is by Professor P. Martin Duncan, whose work, whether technically scientific or of a more popular character, is always good and sound. Taking as his title "The Sea-Shore," Dr. Duncan does not confine his attention to the marine plants and animals which may be picked up on the beach or found in rock-pools, but treats his subject from a broader point of view, so as to show in a general way all the directions in which sea-side rambles may be made interesting and instructive. Thus, by way of defining what is the sea-shore, he indicates the geological phenomena of shore-formation, and passes from these to general considerations on the zones of life fringing our shores, and in a second chapter describes the characteristic terrestrial plants of the shore. In the latter part of this chapter, however, he gives an account of the true littoral sea-weeds; and from this to the last chapter, which treats of the birds, we are throughout confined to the briny element.

The subjects are arranged in systematic order, and the ten chapters relating to animal life furnish an excellent summary of marine zoology, in which the appearance, habits, structure, and physiology of the animals treated of are

* "The Sea-Shore." By Professor P. Martin Duncan, M.B. (Lond.), F.R.S. Sm. 8vo. London: Society for Promoting Christian Knowledge, 1879.

described with great clearness and with an almost total absence of so-called hard words. Indeed, the principal thing that a naturalist would be inclined to find fault with in this book is the, perhaps excessive, avoidance of technicalities, the desire for which has evidently often hampered the author and led him to make use of a phraseology, to say the least of it, a little uncouth. The little book is pretty freely illustrated with fairly good wood-engravings.

BRITISH BIRDS.*

TO the fortunate resident in country places who takes an interest in natural phenomena there are in general no more attractive objects than birds. The most prominent of the living elements of the landscape in most places, interesting from their elegance of form or beauty of plumage, and still more from their habits, the most unobservant of countrymen is perforce to some extent a student of birds, even though his more intimate acquaintance with them may be limited to his boyish experience of plundering their nests, or, somewhat later in life, to a vigorous persecution of them with his first gun. Hence, practically, we find that of all departments of natural history, ornithology is that of which a knowledge (scanty, it is true, in the majority of cases) is most generally diffused, and there is no other group of wild animals about which the desire for knowledge is greater than the class of birds.

Under these circumstances it is no matter for wonder that the literature of British ornithology is tolerably extensive; and, in fact, we have books enough—good, bad, and indifferent—which give a more or less satisfactory account of the characters and habits of the avian inhabitants of these islands. Captain Moore has, however, struck out a new line in this respect, and has produced a most unpretending book, which, we think, will prove of no small use as a work of reference both to the general observer and to the serious student of British birds. In a series of five tables he has systematically arranged the whole list of recorded British birds, and furnished in parallel columns nearly all the information that can be given as to their geographical distribution and migrations. Even the actual list is instructive. The birds are divided into three main categories—residents, migrants, and rare (or occasional) visitants; and the second set are further divided into summer and winter visitants, so that the names of the birds stand in four columns, and the proportion of residents to migrants comes out in a most striking and rather surprising fashion. Thus, one is hardly prepared to see that out of 376 recorded British species only 114 are permanent residents in these islands, whilst 136 are true migrants, or regular summer or winter visitors, and no fewer than 126 fall under the designation of occasional visitants. Of the wading and swimming birds especially, the proportion of wanderers is very large, the number of species of these two orders, which are either migrants or occasional visitors, being about four times as great as that of the permanent residents.

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* "British Birds: systematically arranged in five tables, showing the comparative distribution and periodical migrations, and giving an outline of the geographical range of 376 species." By G. Peter Moore, F.L.S. 4to. London: Van Voorst, 1879.

Now it is with regard to these wandering birds that Captain Moore's tables are particularly interesting, for he indicates their distribution in other countries, and, in the case of migrants, the time of the year in which they are met with elsewhere, thus bringing into a very convenient form for reference a great body of information upon all matters connected with the geographical distribution and migrations of our British birds. Thus, if we take a common and well-known species, such as the martin, we get the following information about it in a single line—it occurs in summer throughout the British islands and all over the Continent of Europe, is a bird of passage in the islands of the Mediterranean, occurs in summer in Iceland and the Faroe Islands, is a rare resident and winter visitant in Palestine, occurs in southern Siberia in summer, in the north-west of India and in Arabia, and in Egypt, Nubia, and Abyssinia in the winter. In northern Africa it is also of course a bird of passage. In like manner with other species the whole distributional history of each is indicated by a few symbols and letters placed in the respective columns under the heads of the different countries inhabited or visited by the birds. The book is in fact a tabulated summary of those points in the Natural History of British Birds which, although of great importance to the ornithologist, will most easily slip his memory, and the author's labour in preparing it, which must have been very considerable, ought to earn for him the gratitude of his fellow-students.

THE HUMAN SPECIES.*

A NATURAL History of Man, written by M. de Quatrefages, forms the twenty-sixth volume of the International Scientific Series, and we need hardly say that, like everything that comes from the pen of its distinguished author, this little work is excellent. M. de Quatrefages, as is well-known, is a strong monogenist in anthropology, and he devotes considerable space here to the development of his views upon the question of the unity or diversity of the species of man, which he settles, of course, in favour of the former. The main argument, naturally, is the unlimited fertility of the human races *inter se*, and the continued fertility of the crossed races, which certainly goes far enough to prove that the differentiation between the races has not advanced to the production of "physiological species." In connection with the question of the origin of mankind, the author also submits the doctrine of evolution to examination, and comes to a decision adverse to the acceptance of any such idea to account for the origin of species, upon grounds which do not appear to us to be of very great weight. The main objections raised by M. de Quatrefages to the doctrine of evolution, or, more properly, to the more advanced developments of Darwinism, are, that its upholders generally give no clear definition of what they understand by a "species;" and, secondly, that they cannot or will not say "they do not know," and therefore are inclined to assume that certain things have happened in accordance with the requirements of their theory, when it is quite possible that

* "The Human Species." By A. de Quatrefages. 8vo. London: C. Kegan Paul & Co., 1879.

just the reverse has taken place. There is, perhaps, some ground for the latter reproach; but at the same time its justice can hardly invalidate the doctrine of evolution, as applied to plants and animals, which rests upon the observation of the phenomena of distribution of organisms in space and time, and by no means upon the success of the attempts that have been made by Darwin, Wallace, and others, to explain how the observed phenomena may have been brought about by secondary causes. The geographical distribution and geological succession of the species of plants and animals present certain general peculiarities which require to be accounted for; the theory that new forms (species) have always come into existence by the modification of the offspring of pre-existing organisms, seems to furnish the only *scientific* method of accounting for the observed facts; and the failure of Mr. Darwin, or of Professor Häckel, to explain all the steps by which the process has been accomplished cannot legitimately shake the theory.

These general biological questions occupy the first two sections of M. de Quatrefages's book, and after dismissing them he proceeds directly to the consideration of his main subject. The third section treats of the antiquity of man, and gives the evidence proving the existence of human beings at remote periods of the existing epoch; and, secondly, those more scanty indications of their having lived in Tertiary times. M. de Quatrefages is inclined to accept the evidence which carries back man in some localities to the Miocene, and seems to think that there is no reason why he should not have had a still higher antiquity. In succeeding books the author proceeds to discuss the original localization of the man, the course of his migrations in peopling the earth, and the phenomena attending his acclimatization in the various parts of it, all, of course, strictly in accordance with monogenistic views. Next, he considers what was the nature of the primitive man, as to which, it must be confessed, he not unnaturally leaves us considerably in the dark; but he maintains that the original formation of distinct races took place under the sole influence of the conditions of life and heredity, to be afterwards modified to a certain extent by intercrossing.

These general and more or less theoretical matters occupy about half the book; in its second half M. de Quatrefages treats first of the earliest races of which we have any reliable remains; and, secondly, of the characters, physical and psychological, of existing races. With regard to the latter he enters into no detailed examination of the different races of man; but discusses those characters and peculiarities, whether of mind or body, which serve for the distinction of races, and, of course, indicates in a general way the particular races in which these peculiarities occur. It is a treatise on the principles of ethnology, and not a formal classification of the races of man.

In taking leave of this very good book, we cannot but express our regret that the publishers do not exercise greater care in the selection of a translator for such works. In the present volume we find passages which are evidently not correctly translated; and the qualifications of the translator for dealing with such a book may be inferred from the fact that in one place he has given "Indian pig" as the equivalent of the French "Cochon d'Inde;" in another "mean Miocene" as the translation of *Miocène moyenne*, and in another ascribes the preservation of the history of the Norse inter-

course with America to Irish instead of Icelandic sagas, and actually calls Erick Upsi, bishop of Greenland in 1121, an Irishman! Surely it would be worth while for the publishers to go to a little extra expense to avoid such blunders as these, and escape from the inevitable suspicion that, where such occur, others, perhaps of more consequence and less easily detected, are to be expected.

TREES AND FERNS.*

MR. HEATH has published a small volume in which he treats of both his favourite subjects—trees and ferns—we presume with the object of reaching a public who would be deterred from purchasing his larger and more expensive books. It is, in fact, merely a reprint of the more general portions of his "Woodland Trees" and "Fern World," with a couple of chapters from the "Fern Paradise." As we have already noticed those works, we need say little about the present one, except that as giving certain details of the structure and mode of growth of ferns and trees in a popular form it may be recommended as tending to foster in the young a taste for botanical studies, and as furnishing a useful guide to the first steps of the beginner. With regard to ferns, some instructions in collecting and growing them are also given. Like Mr. Heath's former publications the little book is prettily illustrated.

* "Trees and Ferns." By Francis George Heath. Sm. 8vo. London: Sampson Low, Marston & Co., 1879.

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

An Elephant-pipe in North America.—Mr. J. D. Putnam has sent to the editors of the "American Naturalist" (see number for April, 1879) photographs of two pipes from a mound in Muscadine County, Iowa, one of them representing a bear, the other an elephant. The latter is so like an elephant in the head, body, limbs, and trunk, that although it shows no tusks, there is said to be no doubt that the maker of it had seen an elephant, and tried to reproduce its likeness in this pipe. Coupled with the discovery of an "elephant mound" in Grant County, Wisconsin, the occurrence of this relic seems to point to the co-existence of man and the mammoth in North America.

Simian Characters in Negro Brains.—Dr. A. J. Parker brought this subject before the Academy of Natural Sciences of Philadelphia (October 8, 1878). In one negro brain out of thirteen that he had examined, he has ascertained the existence of an internal inferior *pli de passage*, which was as well developed as in any of the Simiadæ. In that brain the convolution in question measured a quarter of an inch in width, and completely separated the parieto-occipital or internal perpendicular from the calcarine fissure, so that this region presented the same appearance that it does in the Simiadæ. The same convolution is uniformly present in all those animals, except in *Ateles paniscus*, according to Huxley, and in *Hylobates*, according to Bischoff. It has never before been found fully developed in man, and the absence of this small, bridging convolution has been regarded by some anatomists as a distinguishing characteristic of the human brain, as compared with that of the Anthropoid apes. In another brain of an adult female negro, one of twenty examined since the first discovery of this convolution, it was again met with, fully developed up to the surface, an eighth of an inch wide, and completely separating the two fissures above mentioned. This supposed simian convolution was therefore present in two brains out of thirty-three. Dr. Parker has also observed in the brain of an adult male negro the complete connection of the fissure of Rolando and the fissure of Sylvius.

ASTRONOMY.

Oxygen in the Sun.—Unquestionably the most important astronomical event during the last quarter has been the announcement by Professor

Henry Draper of the series of observations by which he has tested and confirmed the evidence he had obtained in 1877 respecting the presence of oxygen in the sun. It will be remembered that the negatives he had obtained in 1877 were on a scale equal to about one-eighth that of Angström's normal spectrum, the enlargements being four times as great. He has now obtained negatives as large as the former enlargements, or on half the scale of Angström's chart, so that the enlargements (fourfold as before) are on twice the scale of these reference charts. This is of itself a most important advance, indeed it may be doubted whether Professor Draper or anyone else will ever be able to pass much beyond this, seeing that the light of the electric spark in air which gives the comparison spectrum of oxygen, is scarcely equal to one standard candle. By comparison he finds that when the electric spark from his Gramme volatilizes iron, the light is sixty times stronger than the most vivid incandescence of air that he has been able to produce. Still further to improve the air spectrum, and thus to test the reality of the coincidences between the bright oxygen lines in that spectrum and bright parts of the spectrum of the sun, Professor Draper has devised what he calls the spark compresser. The condensed spark taken in the open air, or in a gas under atmospheric pressure, pursues, if unconfined, a zigzag course, and this is apt to produce a widening of the lines in the photographed spectrum. After many experiments, Professor Draper found that the spark might be compressed between plates of thick glass, or better still between two plates of soapstone. When the interval between the plates is directed towards the slit of the spectroscope the lateral flickering of the spark is prevented, while yet the spark is fully exposed to the slit without the intervention of glass or any substance on which the volatilized metal from the terminals could deposit. Very early in the research it became apparent that Plücker's tubes could not be employed with electrical currents of more than a certain intensity, partly on account of the deposit that took place in the capillary portion, and partly because the terminals became so hot as to melt and crack the glass. Moreover, it was desirable to use one terminal of iron so as to be sure that the spectrum of the gas was correctly adjusted to the solar spectrum, and this is impracticable with Plücker's tubes. An additional advantage arises from the soapstone plates, viz., the temperature of the small volume of air between the terminals is materially increased, and increased brightness results. The comparison photographs thus enlarged and purified show as perfect agreement between the oxygen bright bands and the bright parts of the solar spectrum as did those obtained in 1877. The value of the evidence given by each coincidence is increased fourfold; and it need hardly be said that that of the evidence from the complete series of coincidences is increased in much greater degree. In fact, as there are eighteen well-marked coincidences, it might theoretically be argued that the total value of the evidence is increased as $(4)^{18}$ to 1, or some 65,000 millions of times. Although this number can hardly be taken as it stands, yet this may, at any rate be said, that if the evidence obtained in 1877 gave an even chance or even a small degree of probability in favour of the conclusion that there is oxygen in the sun, the evidence of the present series of photographs makes this conclusion so exceedingly probable as to be practically certain. Professor Draper does not go quite so far as this, though he might

safely do so. "On the whole," he said, towards the close of the interesting paper which he read before the Astronomical Society on Friday, June 13, "it does not seem improper for me to take the ground that having shown by photographs that the bright lines of the oxygen-spark spectrum all fall opposite bright parts of the solar spectrum, I have established the probability of the existence of oxygen in the sun. Causes," he proceeded, "that can modify in some measure the character of the bright parts of the solar spectrum, obviously exist in the sun, and these, it may be inferred, exert influence enough to account for such minor differences as may be detected." In closing his paper, Professor Draper called attention to some points indicating the amount of labour and time his researches have already consumed. Each photograph demanded an exposure of fifteen minutes, and with preparation and development at least half an hour was needed. The making of a photograph, exclusive of experiments, required therefore about 30,000 10-inch sparks—that is, 30,000 revolutions of the bobbin of the Gramme machine. In the last three years the Gramme has made 20,000,000 of revolutions. The petroleum engine only consumes a couple of drops of oil at each stroke; and yet it has used up about 150 gallons. Each drop of oil produces two or three 10-inch sparks. "It must also be borne in mind," said Professor Draper, "that comparison spectra can only be made when the sun is shining, and clouds therefore are a fertile source of loss of time."

Mira Ceti.—This star reached its maximum about October 20 last. But an observation made by Mr. Greely of Boston, about three months before this time, would seem to show that there then occurred a well-marked though subordinate maximum. About the middle of August, Mr. Greely early in the morning, in looking for Saturn through the clouds, saw a star which he for a moment mistook for the planet; but its scintillations soon showed that it was not Saturn, but something unusual in that quarter of the sky. The clouds cleared off soon after, giving him an opportunity of noting its brightness, which he says was fully equal to that of any second magnitude star. Being curious to know what this star was, he carefully "memorized" its position (such is the expression used by Professor Sawyer of Cambridge, Mass., in describing Mr. Greely's observations)—the word memorize is not perhaps to be found in the dictionaries, but "'twill serve." On reaching home, Mr. Greely, by means of a star-chart, identified the star as being Mira. The next few nights were cloudy: and when he again saw the star it had greatly decreased in brightness, and shone as a fourth or fifth magnitude star. Professor Sawyer and Mr. Chandler (an observer of variable stars), were at first disposed to place little reliance on this singular observation, not questioning Mr. Greely's statements, but doubting if he had really identified Mira. Subsequent inquiries satisfied them however that he had. If the variations of Mira always followed the ordinary course described in the books, we could not very readily believe that on this particular occasion the star had deviated from its normal series of changes. But as a matter of fact abnormal phenomena have already been noted which tend to render Mr. Greely's statement far less improbable than it might otherwise be considered. Thus in the four years 1672 to 1676, Hevelius, though he searched specially for the star at the times when it should have shone with its maximum brightness (about that of a second magnitude star), failed altogether to detect it.

The Sadler-Smyth controversy.—The question to which we adverted in our last summary has not been dealt with precisely as the friends of the late Admiral Smyth could have wished. Instead of an examination of the singular instances of discrepancy from fact and agreement with the errors of others noticed by Messrs. Burnham and Sadler, which could not but have resulted either in clearing Admiral Smyth's memory from all suspicion, or else in showing that unfortunately the doubts which seem to be suggested by Mr. Sadler's recent paper were well founded, the matter has been simply dropped, the council of the Astronomical Society publishing a statement implying their regret that they ever allowed it to be taken up. A tone was adopted in discussing the matter which implied further, that whatever corrections may be made as to scientific statements, none which would suggest the possibility of fraud should ever be published. It was understood that this was specially urged by the Astronomer Royal, who being personally interested in the matter (not simply as a friend of Admiral Smyth's, but as having practically pledged himself to the value of Smyth's observations—now admitted to be almost valueless as a series) might perhaps with better taste have remained silent. But apart from this it was rather singular to hear the author of the most virulent personal attack recorded in the history of astronomy, that, namely, in which Father Hell was not only accused of bad and careless observation, but directly charged with personal fraud, adopting a tone which perhaps might have seemed correct enough, if rather affected, in the case of one who had never offended against propriety in such matters. We are glad, however, to find that Mr. Burnham emphatically accepts the interpretation placed by Mr. Proctor on the words "stupendous fraud," applied by Mr. Burnham to Admiral Smyth's work. He cannot understand, he says, how this could ever have been understood to imply personal fraud on the admiral's part: but herein we cannot quite agree with him, for in England that would be the natural interpretation of such an expression. But every one acquainted with American modes of expression, knew that the word "fraud," as used by Mr. Burnham, did not necessarily or even probably imply any personal reflection on the admiral, but simply indicated that his book was disappointing and unsatisfactory.

Spectrum of Brorsen's Comet.—The following observations of this interesting object have been made at Greenwich, and are communicated by the Astronomer Royal. The dispersion used was that of one compound "half-prism," equivalent to four flint prisms of 60° (20° from A to H), with a power of 12 on the viewing telescope. The spectroscope was mounted on the Great Equatorial.

The spectrum consists of the three usual cometary bands, corresponding to the three principal bands of the second spectrum of carbon, and does not present the anomalous appearance found by Dr. Huggins in 1868. The bands were compared on several evenings with those shown by a vacuum tube containing vapour of alcohol at a pressure of 1·2 m.m., and the coincidence appeared sensibly perfect.

The position of the brighest comet-band (in the green) was measured with Hilger's bright line micrometer on two evenings, April 19 and 28, by Mr. Maunder; on other occasions it was compared with the corresponding carbon-band indirectly by means of a movable bar in the eyepiece, 30 tenth-

metres broad. The following are the results of the micrometer readings for the less refrangible edge of the comet-band referred to the centre of the brightest portion of the carbon-band, which (with a narrow slit) is less than 5 tenth-metres broad:—

1879.	Comet-band.	Wave-length inferred.	Width of slit. in.
April 19	0·5 tenth-metres to blue	5190	0·009 = 16 tenth-metres.
28	4·5 ,, to red	5191	0·013 = 24 ..

The wave-length of the less refrangible edge of the carbon-band (alcohol vapour in a vacuum tube) has been taken at 5198·3 tenth-metres. As it was not found practicable to use a narrower slit, there is probably an uncertainty of several tenth-metres in the position of the comet-band, but it appears from these observations that it coincides approximately with the band in the second spectrum of carbon (vacuum tube) at 5198, and not with that in the first spectrum (blue flame of Bunsen burner) at 5165. On April 17 several comparisons were made by Mr. Christie, by bringing up a movable bar from the blue end of the spectrum so as just not to hide the bright edge of the comet-band, and in every case the coincidence of the less refrangible edges of the comet and alcohol-bands appeared sensibly perfect. In these observations the slit was of such a width that the bright line, with which the alcohol-band commences, had a breadth of about 30 tenth-metres. The principal comet-band extended about ⅔ of the way towards F, to about wave-length 5,000, its blue end appearing to coincide approximately with a faint band of alcohol.

The second comet-band in the yellow was measured on April 28 by Mr. Maunder, and its red edge was found to be 2·4 tenth-metres to the red of the middle of the brightest part of the alcohol-band at 5610. The slit, however, was very wide, viz. $0^{in}\cdot033$, corresponding to 65 tenth-metres. This measure would place the red edge of the comet-band at 5580, whilst the band in the first spectrum of carbon is at 5635. The more refrangible end of the yellow band appeared to coincide with a well-marked band in the alcohol spectrum. The third comet-band was very faint; it appeared to be in the neighbourhood of the blue band of alcohol at 4835. The relative brightness of the three bands was estimated thus: Green, 10; Yellow, 3; Blue, ½.

At Lord Lindsay's observatory Dunecht, the following observations were made:—

1879, April 12, at $12^h\ 9^m$ S.M.T., the comet was well seen between clouds. It had a ray-like tail, which could be traced for about 25′ from the highly condensed nucleus. The coma was obviously elongated at right angles to the direction of the tail, its greatest diameter being about 5′. Clouds prevented further observations.

April 16, $10^h\ 30^m$ S.M.T., tail 10′ long, in position 57°·8 by six measures with powers 122 and 229. No structure could be detected in the nucleus with powers 229 or 312.

April 17, $12^h\ 56^m$ S.M.T., tail 13′ long, in position 51°·0 from three measures with power 122.

The spectrum was observed on April 16, May 2 and 3.

It consisted of three broad bands, the brightest parts of which had the following wave-lengths:—

	m.m.m.
No. 1	547·6
2	515·6
3	469·6

Nos. 2 and 3 were sharply bounded on the less refrangible side, fading off gradually towards the violet. No. 1 was very ill-defined on both sides, and, being without any definite brighter part, its wave-length is very uncertain. Observers, Ralph Copeland and J. G. Lohse.

Phenomena for the Quarter.—The sun will be eclipsed, but not visibly in England, on July 18. Venus will be at her greatest brilliancy, as an evening star, on August 19; and in inferior conjunction with the sun on September 24. Mercury will be in inferior injunction on August 24. Jupiter will be in opposition to the sun on August 31. Saturn (this however belongs to the following quarter) on October 5.

BOTANY.

The Black Mildew of Walls.—In "Science Gossip" for August last there was an article by Professor Paley, entitled "Is the Blackness on St. Paul's merely the Effect of Smoke," in which the author maintained that this blackness is chiefly due to the growth of an undescribed lichen, which appears to flourish only on limestone and in situations unaffected by the direct rays of the sun. Professor Leidy, calling the attention of the Academy of Natural Sciences of Philadelphia to this paper (September 3, 1878), remarked that he had himself many years ago noted a similar black appearance on the brick walls and granite work of houses in narrow shaded streets, especially near the Delaware River. Noticing a similar blackness on the bricks above the windows of a brewery, from which there was a constant escape of watery vapour, he was led to suspect that it was of vegetable nature. On examination it proved to be caused by an Alga, closely allied to what he regarded as *Protococcus viridis*, which gives the bright green colour to the trunks of trees, fences, and walls, usually on the shady side. It may be the same plant in a different state, but until this is proved he proposes to name it *Protococcus lugubris*. It consists of minute round or oval cells, from 0·006 to 0·009 millim. in diameter, isolated, or in pairs or groups of four, the result of division, or in short irregular chains of from four to a dozen, sometimes with a lateral offshoot of two or more cells.

Irritable or Sensitive Stamens.—In Part III. of the "Proceedings of the Academy of Natural Sciences of Philadelphia" for 1878, Mr. Thomas Meehan calls attention to the large number of plants now known which exhibit an irritative motion in some of their parts, and states that from his observations of plants of the orders *Bignoniaceæ*, *Scrophulariaceæ*, and *Acanthaceæ*, he has arrived at the conclusion that wherever there are bilobed flattened stigmas in these orders this sensitiveness to touch would be exhibited in a greater or less degree. He then remarks upon the fact that though in the *Opuntiæ*, a genus of *Cactaceæ*, the stamens move in various directions when

touched, yet no such motion had been observed in *Cereus*, *Mammillaria*, and other allied genera of the order; he had, however, noticed a similar motion in the stamens of the common garden *Portulaca grandiflora*, and in the Purslane, *Portulaca oleracea*. In another Portulaceous plant, *Talinum patens*, the expanded stamens fall down on the petals when touched, while, strangely enough, no trace of motion could be detected in *Talinum teretifolium*, though in a West Indian species which was found growing in a botanical garden in St. Louis the expanded stamens fell down on the petals when touched, and he thought it remarkable that this power should exist in *T. patens* and not in *T. teretifolium*.

Mr. Meehan suggests that the objects of these movements may yet form an interesting study, pointing out that in *Dionæa*, *Drosera*, and some others, the motion had been found to result in some immediate benefit to the plant; while in *Mimosa*, *Hedysarum*, and others, no such immediate benefit had been observed. In the case of sensitive stigmas, they had been supposed to have some reference to arrangements for cross-fertilization, but this he considered doubtful on these grounds:—In the case of *Mimulus ringens* the stigmas expand, and the anthers disperse their pollen before the corolla is quite open, and pollen may be generally found on the stigmatic surfaces when the mouth exposes these parts to view. In *Tecoma radicans*, on the other hand, the lobes of the pistil do not expand till some time after the mouth of the corolla is open, and in many cases pollen-hunting bees had carried away all the pollen before these lobes had expanded.

In cases where the expansion of the lobes and dispersion of the pollen were simultaneous, it was theoretically supposed that a bee or insect touched the lobes with its pollen-covered head or back, and that the lobes then closed against the admission of pollen on the withdrawal of the insect from the flower; but he had found that the bees in the cases observed by him occupied but from three to five seconds in visiting a flower, while it took from thirty to sixty seconds for the lobes to close, and then they were seldom so completely closed as to render the reception of fresh pollen difficult. Mr. Meehan had therefore come to the conclusion that the hypothesis in relation to cross-fertilization was untenable, and that the real use of this motion in the economy of nature still remained an open and promising field to the future investigator.

CHEMISTRY.

The Formation of Organic Ultramarines.—De Forcrand has already shown that the ultramarines of different metals may be obtained by allowing the chloride of the metal selected to act upon the silver ultramarine, and the idea occurred to him that the process might be extended to the chlorides or iodides of different alcoholic radicles. The silver compound was heated to 130° for from fifty to sixty hours with an excess of ethyl iodide. After the operation had gone on for from ten to fifteen hours the tube was opened, the product washed with alcohol, hyposulphite of soda, and water, and again placed in the tube with an excess of iodide. This process was repeated several times,

till, in fact, the carefully-washed product contained no more silver. The final product has a light grey colour, and is decomposed when heated, ethyl-sulphide being evolved. If it is previously strongly heated with sodium chloride no ethyl sulphide is given off, the grey powder turns blue, and the original ultramarine, with all its properties, is formed. In order to show that the ethyl really entered into the constitution of the ultramarine, the products of the action of heat on the body were collected in mercury chloride; the crystalline precipitate had the composition $(C_2H_5)_2S,H_gCl_2$, from which it is apparent that the ethyl actually formed a constituent. Similar reactions were observed with the iodides of other alcohol radicles and with some quaternary ammonium iodides.—(*Compt. rend.* lxxxvii. 30.)

Oxidation of Quinine with Potassium Permanganate.—According to the experiments of S. Hoogewerff and W. A. Van Dorp, during the oxidation of quinine by this method a part of the nitrogen is removed in the form of ammonia. Some oxalic acid is formed, as well as a nitrogenous base, which separates in transparent crystals, and melts at 244°. This new body is tribasic, and has the formula $C_8H_5NO_6$. A number of its salts have been prepared. Quinidin, as well as cinchonine, appears to furnish the same product when oxidized, and it appears to be tricarbopyridinic acid, $C_5H_2N(COOH)_3$.—(*Ber. chem. Gesell.* xii. 158.)

Lactucone.—N. Franchimont reports his having obtained a considerable quantity of lactucarium out of *Lactuca altissima*, from De Vrij, and his having induced Wigman to prepare the lactucone from it, and to compare it with betulin. He obtained it in the form of microscopic needles, insoluble in water, soluble with difficulty in alcohol, easily soluble in petroleum, and melting at 296°. Analysis pointed to the formula $C_{14}H_{24}O$, which does not accord with those adopted by Senior and Ludwig. An acetyl derivative could not be obtained; and phosphorus pentasulphide, by the withdrawal of water, left a hydrocarbon of the form $C_{14}H_{22}$. Lactucone appears to be homologous with camphor and the zeorine of Paterno.—(*Ber. chem. Gesell.* xii. 10).

Eikosylene.—This body is a derivative of the paraffin of coal tar. E. Lippmann and J. Hawliczek find that nearly all the paraffin met with in commerce contains oxygen. The specimens on which they operated were treated with sodium to remove it. To introduce chlorine into these purified products they employed phosphorus pentachloride, which was added to the solution of the paraffin in carbon tetrachloride, and heated with it. In this way a chloride having the formula $C_{20}H_{39}Cl$ was obtained, which, when distilled under ordinary atmospheric pressure, gave up its chlorine in the form of hydrogen chloride, the hydrocarbon to which they have given the name of eikosylene, and which has the formula $C_{20}H_{38}$, remaining isolated. It possesses all the characters of an olefine, and forms a second chloro-derivative, having the composition $C_{20}H_{38}Cl_2$. Eikosylene is consequently homologous with cetylene $C_{16}H_{30}$, and may be regarded as a high member of the acetylene series.—(*Ber. chem. Gesell.* xii. 62).

The Transformation of Starch into Dextrose in the Cold.—Starch, it is known, is slowly transformed into dextrose when boiled for a long time with water. Riban has made some observations which seem to show that the same result may be arrived at in the cold, though much more gradually. A

solution formed by boiling one part of finely-divided starch in one hundred of water saturated with salt, and filtering the same, is imputrescible, and may be preserved for a long time. After a year the author's solution appeared to be less sensitive to iodine, and after three or four years was no longer coloured by that reagent. It was neutral, limpid, contained no trace of any organized ferment, reduced the copper solution energetically, and was coloured brown by alkalies. Determined by the copper test, every 100 cc. contained 0·111 gramme of dextrose; but when ferrocyanide of potassium was employed, which is not affected by dextrin, 100 cc. contained 0·102 gramme. A mixture of nine-tenths dextrose and one-tenth dextrin was consequently formed from the starch. The solution in a tube 200 mm. long rotated to the right: $D\alpha = +0·15°$. The author calls attention to the importance of the transformation of starch in the cold without a ferment in its bearing on the physiology of vegetable growth.—(*Bull. Soc. Chim.* xxxi. 10).

The Action of Isomorphous Salts in Exciting the Crystallization of Supersaturated Solutions of each other.—Mr. John M. Thomson, of King's College, has read a paper on this subject before the Chemical Society (*Journ. Chem. Soc.*, May 1879). He points out that two explanations have been put forward to account for this action. One, that the crystallization is induced by the entrance of a particle of the same salt; and the other, that, a purely physical cause, such as the presence of greasy, fatty, or oily matter in thin films, may be found active in exciting the crystallization. A solution of potassium tri-iodide, which had remained under a desiccator for a considerable time without change, was found after a short exposure to the air to be filled with crystals of the tri-iodide. The solution had undergone supersaturation, and its deliquescent nature would most likely prevent its floating in the air as a solid: it obviously was not a particle of the salt itself which excited the crystallization. In his experiments the supersaturated solution was placed in a flask, and that of an isomorphous salt to be employed as nucleus in a thin glass bulb, which was supported in the neck of the flask with a plug of cotton wool. The solution in the bulb-tube having been boiled, the tube was stoppered with cotton wool. The contents of the flask were again boiled, and the arrangement placed aside for eighteen or twenty hours. To perform an experiment the solution in the bulb-tube was crystallized by touching it with a platinum wire, and the bulb-tube lowered into the liquid of the flask, allowed to remain there some time to see that the introduction of the glass into the fluid did not cause crystallization, and finally lightly broken in the fluid. Only a few examples of activity can be mentioned here. The action of isomorphous sulphates on magnesium sulphate was very successful. Zinc and nickel sulphate were active at once; cobalt and iron sulphate after some time; nickel sulphate with $6H_2O$, iron sulphate with xH_2O, and cobalt sulphate with xH_2O after some time. Sodium selenate with sodium sulphate crystallized immediately; chromium and iron alums with common alum were active. Hydrodisodic arsenate with the corresponding phosphate crystallized immediately and very rapidly. The experiments with the sulphates of nickel, magnesium, and zinc confirm the results of Gernez, published in 1866. The general results arrived at by Mr. Thomson are:—(A) When the mixture consists of two salts which are not isomorphous: (1) Sudden crystallization may take place, gradually spreading

through the solution on the addition of a nucleus, causing a deposition of the body belonging to the nucleus only; (2) That when sudden crystallization takes place, causing the deposition of both salts, there is a preponderance of the salt of the same nature as the nucleus; (3) That the nucleus may remain growing slowly in the solution, becoming increased by a deposition of the salt of the same nature as the nucleus. And (B) When the mixture consists of two isomorphous salts: (1) Sudden crystallization may occur giving a deposition of both salts, apparently in the proportion in which they exist in solution; (2) That when slow crystallization takes place, the nucleus increases by a deposition of the least soluble salt, showing that in mixed supersaturated solutions a gradation of phenomena may be experienced, passing from those shown in the crystallization of a true supersaturated solution to those shown in the crystallization of an ordinary saturated solution.

New Compounds of Ammonia and Hydrogen Chloride.—Hydrochloric acid and ammonia have hitherto been known only in one form of combination, that of sal-ammoniac, analogous to salt and potassium chloride. Troost, during his experiments on the vapour density of ammonia compounds, has found a number of curious compounds which dry ammonia forms with hydro gen chloride, sulphuretted hydrogen, and a number of other mineral and organic acids. In a recent communication to the Paris Academy of Sciences (*Compt. rend.* lxxxviii. 578) he describes two new compounds of ammonia and hydrochloric acid. The first contains four equivalents of ammonia and one of the acid; it melts at $+7°$, its crystals energetically depolarize light, and therefore do not belong to the same crystalline system as salammoniac; it is anhydrous and has the formula $HCl, 4NH_4$. The second compound contains seven equivalents of ammonia and one equivalent of the acid. It melts at $-18°$; the liquid exhibits all the characters of supersaturation; if rapidly cooled it becomes viscous; and at $-40°$ becomes a transparent solid mass. It has the composition $HCl, 7NH_3$.

GEOLOGY AND PALÆONTOLOGY.

Carboniferous Fenestellidæ.—Mr. G. W. Shrubsole has communicated to the Geological Society (February 21, 1879), the results of his investigations on the British Carboniferous Fenestellidæ. He finds that owing to neglect on the part of describers to allow for differences in the structure at various stages of growth and in different parts of the polyzoarium a great number of unnecessary species have been made; out the twenty-four recorded species of *Fenestellæ* he has examined nineteen, and his investigations lead him to reduce these to five.

Tertiary Fossils of Chili.—Descriptions of tertiary fossils from Chili have been given by various authors, especially D'Orbigny, G. B. Sowerby (in Darwin's "Geological Observations,") and Claude Gay. Dr. R. A. Philippi now publishes (*Zeitschr. für die gesammten Naturwiss.*, 1878), a notice of the forms contained in the Museum at Santiago, preliminary to a more detailed memoir, which will contain the descriptions of numerous new species. From the tertiary deposits of Chili and the dependent islands, he records a great

number of mollusca—1 Pteropod, 15 Gasteropoda, 188 Bivalves, and 5 Brachiopods—and species of *Nautilus* and *Baculites* also occur. Of other invertebrate groups Dr. Philippi notices Annelids, Echinoderms, and Zoophytes, or rather Bryozoa; whilst the vertebrata are represented by a few fish-remains, a *Plesiosaurus* and a whale. Of the eighty-one genera of mollusca, three, namely *Baculites*, *Cinulia*, and *Trigonia*, may be regarded as showing Cretaceous affinities, and the *Baculites* and *Plesiosaurus chilensis*, especially, have been regarded as more properly belonging to the Cretaceous series. Dr. Philippi has, however, obtained specimens of both species along with undoubted Tertiary fossils, and hence he is inclined to draw a parallel between the phenomena presented by this part of the geological series in Chili and in New Zealand, where, as is well known, Dr. Hector recognizes what he calls "Cretaceo-tertiary" strata. From the scarcity of forms proper to warm climates, and especially the absence of corals and Polythalamia, Dr. Philippi infers that at the period represented by these beds there may have been already a cold current flowing to this region from the Pole. An interesting point which comes out from his table of the molluscan genera is that the tertiary fauna of Chili possessed a much greater similarity to the existing fauna of the Mediterranean than to that of the neighbouring coasts. It included at least twenty-five important genera, now entirely wanting on the Chilian coast, but all, with the exception of *Perna*, represented in the Mediterranean.

Among the remains of fish, which are generally so fragmentary as to be incapable of determinination, Dr. Philippi records the discovery of the tooth of a species of *Carcharodon*, which is interesting from its relationship to the gigantic teeth belonging to the same genus found in the Tertiaries of the Mediterranean region. The author describes it as belonging to a distinct species under the name of *Carcharodon gigas*; it differs from the well-known *Carcharodon megalodon* at first sight by its obliquity; its convex side is obtusely ridged, and its margins are less regularly and less deeply notched than those of the European species. The length of the longer margin of the tooth was about 4½ inches.

Polydactyle Horses.—Professor Marsh has an article on this subject in the "American Journal" for June 1879, which, besides describing his observations on recent horses with supplementary digits, gives an interesting summary of the palæontological facts bearing on the question of the supposed parentage of existing Solidungulates. It appears that the most common form of polydactylism in living horses is the presence of an extra small toe and hoof on the inside, either of the anterior pair or of all four feet, but Professor Marsh has lately heard of a colt with three toes on one fore foot and two on the other, and of a mare (still living) which has three toes on each fore foot and a small extra digit on each hind foot. The more frequent presence of extra digits on the fore foot is what might be expected; but the abnormal development of the toe on the inside is curious, both because in general the second digit is less persistent than the fourth, and because, when developed, it would seem to be rather in the way.

Of the American series of precursors of the horse, Professor Marsh speaks as follows: "If we examine the remains of the oldest representatives of the horse in this country, we shall find that these animals were all polydactyle

and of small size. As the line was continued towards the present era, there was a gradual increase in size, and a diminution in the number of toes, until the present type of horse was produced. . . . . The original ancestor of the horse, not as yet discovered, undoubtedly had five toes on each foot. The oldest member of the group now known is the *Eohippus*, which had four well-developed toes and the rudiment of another on each fore foot, and three toes behind. This animal was about as large as a fox, and its remains are from the Coryphodon beds, near the base of the Eocene. In the next higher division of the Eocene, another equine genus, *Orohippus*, makes its appearance. It resembled its predecessor in size, but had only four toes in front, and three behind. At the top of the Eocene, a third allied genus has been found (*Epihippus*), which closely resembled *Orohippus* in its digits, but differed in its teeth. Near the base of the next formation, the Miocene, another equine mammal (*Mesohippus*) occurs. This animal was about as large as a sheep, and had three usable toes, and the splint of another, on each fore foot, with but three toes behind. At a somewhat higher horizon, a nearly allied genus (*Miohippus*) has been found, which has the splint, even of the outer or fifth digit, reduced to a short remnant. In the Pliocene above, a three-toed horse (*Protohippus*), about as large as a donkey, was abundant; and still higher up a near ally of the modern horse, with only a single toe on each foot (*Pliohippus*), makes his appearance. A true *Equus*, as large as the existing horse, appears just above this horizon, and the series is complete." These remarks are illustrated with an interesting series of figures showing the structure of the fore and hind feet, the fore-arm, the leg, and the upper and lower molars in each genus.

A Moravian Cave.—In an article communicated to the Academy of Sciences of Vienna, Dr. K. T. Liebe notices the contents of the cavern of Vijpustek, near Kiritein, in Moravia. The bones of Mammalia found in this cave represent the following species:—*Lynx vulgaris* (lynx), *Felis Catus* (wild cat), *Canis spelæus* (Diluvial wolf), *Canis familiaris* (dog), *Vulpes vulgaris* (fox), *V. lagopus* (Arctic fox), *Gulo borealis* (glutton), *Martes abietinum* (pine martin), *Fœtorius putorius* (polecat), *F. erminea* (ermine), *Vesperugo serotinus* (Serotine bat), *Arvicola* sp. (vole), *A. amphibius* (water-rat), *Lepus variabilis* or *timidus* (mountain hare), *Cricetus frumentarius* (hamster), *Myoxus Glis* (dormouse), and *Sciurus vulgaris* (squirrel). Dr. von Hochstetter states that besides these seventeen species the cave contains remains of *Elephas primigenius* (mammoth), *Rhinoceros tichorhinus* (woolly rhinoceros), *Equus fossilis* (horse), *Bos priscus* (aurochs), *Cervus tarandus* (reindeer), *C. capreolus* (roe-deer), *C. eurycercus* (?), *Capra Ibex* (ibex), *Ursus spelæus* (cave bear), *Felis spelæa* (cave lion), and *Hyæna spelæa* (cave hyæna), so that twenty-nine species of mammals are known from the cave.

A comparison of these bones with those obtained from the caves of Thuringia leads to some interesting results. It is clear that the cave of Vijpustek was a den occupied for long periods, now by families of hyænas, now by families of bears, and occasionally visited by cave lions, wolves, and lynxes; whilst its numerous side-galleries, some of which probably opened directly into the outer air, harboured smaller beasts of prey, such as the polecat, marten, and glutton. A few animals, indeed, may have been floated as carcasses into the cave; but the greater part of the remains are those

either of animals which inhabited it and died in it, or of such as were dragged in as prey by these residents. The whole fauna of the cave is essentially a forest fauna, proving that in later diluvial times its neighbourhood was forest-clad; whilst the investigation of the Thuringian caves and other deposits of the same period in North Germany show equally clearly that the whole of that country was then a naked steppe quite destitute of forests. Hence it would appear that the mountainous and hilly country of southern Bohemia and Moravia was the starting point from which the primeval forest spread over the great diluvial steppe of Central Europe north of the Alps.—(*K. Akad. Wiss. Wien*, 23rd May, 1879.)

An Anthropoid Ape in the Siwáliks.—Mr. Lydekker announces the discovery by Mr. Theobald of the upper jaw and palate of a large anthropoid ape in the Siwáliks of the Punjab. It belonged to a female animal, judging from the small size of the canines, and indicates a creature intermediate in size between the orang and the gorilla. The molars are of the ordinary anthropoid type; but the premolars are much narrower than in any known anthropoid ape, and indeed relatively narrower than even in man; and the small size of the last molar and of the incisor are also points giving the jaw a human character. The chimpanzee, of living apes, comes nearest to this fossil. The specimen is of great interest as being the first trace of the large anthropoid apes found in India, and from its resemblance to the chimpanzee and gorilla, the great apes of Western Africa.—*Proc. Asiat. Soc. Bengal*, December 1878.

The Glaciation of the Shetland Isles.—On March 26 Messrs. Peach and Horne communicated to the Geological Society an elaborate paper on the Shetland Isles, in which they described the different islands, reviewing in succession the physical features, geological structure, the direction of glaciation, and the various superficial deposits. From an examination of the numerous striated surfaces, as well as from the distribution of Boulder-clay and the dispersal of stones in that deposit, they inferred that during the period of extreme cold Shetland must have been glaciated by the Scandinavian Mer de Glace, crossing the islands from the North Sea towards the Atlantic. In the island of Uist, blocks of serpentine and gabbro are found in the boulder-clay on the western shores derived from the rock-masses occurring on the east side of the watershed. Moreover, on the mainland between Scalloway and Fitful Head, blocks derived from the Old-Red-Sandstone formation on the eastern sea-board are abundant in the Boulder-clay on the west side of the watershed. The relative distribution of these stones in the sections on the west coast is in direct proportion to the relative areas occupied by the rocks on the east side of the watershed. It was likewise pointed out that after the period of general glaciation Shetland nourished a series of local glaciers which radiated from the high grounds, the direction of the striæ being at variance with the older system, while the morainic deposits also differ in character from the Boulder-clay produced by the great Mer de Glace.

The authors described the order of succession in the Old-Red-Sandstone formation in Shetland, and referred to the discovery of an abundant series of plant-remains in rocks which have hitherto been regarded as forming part of the series of ancient crystalline rocks. The plant-remains are identical with

those found in the Old-Red-Sandstone rocks in Caithness, Orkney, and Shetland, from which it was inferred that the quartzites and shales in which the fossils are imbedded must be classed with this formation. The authors also described the great series of contemporaneous and intrusive igneous rocks of Old-Red-Sandstone age, adducing evidence in proof of the great denudation which has taken place in the members of this formation in Shetland.

A Silurian Area near Cardiff.—Mr. Sollas described to the Geological Society, on April 9, the occurrence of unmistakable Silurian rocks about Rhymney and Pen-y-lan, near Cardiff. They comprise beds belonging to the Wenlock and Ludlow groups, and pass conformably upwards into the Old Red Sandstone. The district affords a good base for a measurement of the thickness of the Old Red Sandstone on the south of the South Wales coalfield. This was found to be a little over 4,000 feet. The thinning out of the Old Red Sandstone and Silurian strata, together with the marked change which takes place correspondingly in the lithological characters of the latter formation on passing from the north to the south side of the coalfield were taken to indicate an approach to a shore-line. This shore-line belonged to land which, as shown by the great thickness of the Devonian beds, could not have extended far south. It corresponded to Mr. Etheridge's barrier between the Old Red Sandstone and Devonian seas. The sandstones with Old-Red characters, such as the Hangman Grit and the Pickwell-down Sandstones, occurring in the Devonian formation, were deposited at intervals when this barrier was submerged to a greater depth than usual. The Cornstones were stated to thin out to the south along with the other sedimentary beds of the Old Red Sandstone, and were regarded as derived from the denudation of previously upheaved limestones, such as the Bala and Hirnant. The paper concluded with a description of the characters of the more interesting rocks and fossils.

Were Ichthyosaurs Viviparous?—Professor H. G. Seeley laid before the Geological Society at its last meeting the evidence which seemed to him to show that certain species of *Ichthyosaurus* might possibly have produced living young. He described several specimens in which the remains of one or more small individuals have been preserved within the body-cavity of larger ones. One of these was described and figured in 1822, by Jäger; a notice of another was published in 1846 by Dr. Chaning-Pearce, who suggested that it furnished evidence in favour of the viviparity of the Ichthyosaurs. Other examples are preserved in museums in Germany, and one in Madrid, and most of them have been examined by the author, who adduces the state of preservation of the small individuals, in contrast with that of the traces of fish and Cephalopoda, the remains of food, which are found in the stomachal region of the larger individuals, in advance of the position occupied by the smaller ones, as a proof that we have not here to do with a case of cannibalism. The position of the smaller skeletons with the head generally turned towards the pelvic region of the larger ones is also regarded as indicative of their standing in the relation of parent and offspring. As some of the young specimens possess limbs it would seem that the supposition that the Ichthyosaurus passed through a sort of tadpole stage is erroneous. It must be observed, however, that, as we are entitled *à priori* to assume that the Ichthyosaurs, if they produced living young, were

merely ovo-viviparous, after the fashion of those reptiles of the present day whose offspring are brought into the world alive and free, the large size of some, at least, of the young examples cited by Professor Seeley is hardly reconcilable with the idea of their embryonic condition.

A New Type of Pterodactyles.—At the last meeting of the Geological Society Professor Seeley described the characters presented by the impression of the skull of an Ornithosaur in a slab of Stonesfield-slate from Kineton near Stow-on-the-Wold, the peculiarities of which are such as to induce him to found for it a new genus, to which he thinks it probable that most, if not all, the known Stonesfield-slate Pterodactyles may belong. It is distinguished especially by the great length of the roof of the skull posterior to the orbits, by the presence of a very deep constriction of the frontal region between the orbits, by the strongly marked sutures between the bones, and by the curiously crocodilian character of the plan of structure of the roof of the skull, which suggests the existence of a lower grade of Ornithosaurian animals than has hitherto been suspected. The genus appears to be allied to some forms of *Rhamphorhynchus*. The author names the species, which is in the Oxford Museum, *Rhamphocephalus Prestwichi*, and considers that the other bones of Ornithosauria discovered in the Stonesfield Slate support the generic separation of the group.

New Fossil Crustacea.—On May 28, Dr. Henry Woodward communicated to the Geological Society descriptions of four new Fossil Crustacea possessing considerable interest. Three of them are regarded as Stomapods of the family Squillidæ, and one of these is especially interesting, if correctly referred to that group, as carrying back the Squilliform Crustacea in time to the middle Coal-measures. The specimen was found by Mr. E. Wilson, of Nottingham, in a nodule of Clay-ironstone from Corsall, near Ilkeston, in Derbyshire, but is, unfortunately, very imperfect, consisting only of the four posterior abdominal segments and the telson. Dr. Woodward names it *Necroscilla Wilsoni*, and thinks it probable that it is allied to the genus *Diplostylus*, Salter, from the Coal-measures of the Joggins, Nova Scotia.

A true *Squilla* was described under the name of *Squilla Wetherelli* from a specimen preserved in a phosphatic nodule of the London Clay of Highgate, forming part of the late Mr. Wetherell's collection. It is of interest from its resemblance in characters to the existing species of the family, its nearest ally being a recent Australian species, unnamed, but related to the well-known *Squilla Desmarestii*.

A second *Squilla*, this time from the Cretaceous deposits of the Lebanon, is also most nearly related to the Australian species above-mentioned, the segments not being ornamented with spines and ridges as in most recent forms. The specimen occurs in a collection made by Professor E. R. Lewis, of Beirût, consisting chiefly of the remains of fishes preserved in a compact cream-coloured limestone. It was named *Squilla Lewisii*. In the same collection there was the most interesting of all the species described by Dr. Woodward on this occasion, namely, a fossil king crab (named by the author *Limulus syriacus*), well-preserved in a slab of the same cream-coloured limestone. From a palæontological point of view the discovery of this new king crab is very important, as it helps to bridge over the gap previously intervening between the Jurassic *Limuli* of Solenhofen and those of our present seas.

Iguanodon in the Kimmeridge Clay.—Professor Prestwich announces (*Geological Magazine*, May 1879) a most interesting discovery which has lately been made at Cumnor Hurst, near Oxford. The workmen engaged in the brickfield there found, in digging, a quantity of bones, which they brought to the Museum at Oxford, and which, on being cleaned, displayed the characteristic peculiarities of *Iguanodon*. Many of the vertebræ are entire; the jaw, although in fragments, contains many teeth in position; and one of the feet, with the claw-joints, is almost complete. The larger bones are nearly all broken; but many of them may probably be united, and it is believed that the skeleton was nearly complete when found. The animal is smaller than the Wealden *Iguanodon Mantelli*, and may perhaps be a young individual of that species, but Professor Prestwich is inclined to regard it as a distinct species, with smaller and more delicately formed bones. On visiting the spot, Professor Prestwich learned that the bones had been found in a seam of yellow sandy clay two or three inches thick, at a depth of about four feet, and the clay above this seam contained perfectly characteristic Kimmeridge Clay shells, such as *Exogyra virgula*, *Cardium striatulum*, *Thracia depressa*, and *Ammonites biplex*, with *Lima pectiniformis* and *Serpulæ*. Hence it would appear that *Iguanodon*, or some closely allied Dinosaur, was not confined to the Lower Cretaceous and Wealden periods, but existed also during that of the Kimmeridge Clay.

MINERALOGY.

The Presence of Didymium and Cerium in Minerals.—As Horner has shown the presence of these metals in different pyromorphites and scheelites by aid of the spectroscope, so Cossa has now recognized them in apatites, scheelites, osteolites, and coprolites, not only by means of the spectroscope, but by separating them in the form of oxalates. He has also found the cerium metals in marble and in bones. From a kilogramme of Carrara marble two centigrammes of cerium oxalate were obtained. The muschelkalk of Avellino is found to contain still larger quantities of cerium compounds. A kilogramme of washed bone ashes, such as is used for the formation of cupels, yielded three centigrammes of cerium oxalate. These observations go to show that the cerium metals are widely spread throughout nature. Cossa is at present occupied with an examination of natural phosphates and the ashes of plants.—(*Ber. chem. Gesell.* xi. 1837.)

Artificial Formation of Nepheline and Leucite.—We some time since directed attention to the method employed by F. Fouqué and A. Michel Levy to form felspars artificially. By the same method they have recently prepared the minerals above mentioned. Nepheline is formed when a mixture of silicic acid, alumina, and sodium carbonate, in such proportions that the oxygen of protoxide, sesquioxide and acid are as 1 : 3 : 4, are heated together; white silk-like crystals are obtained which under the microscope are seen to be small hexagonal prisms (they are 0·12 min. long, and 0·06 min. broad), which accord in every respect with natural crystals of nepheline. If somewhat more silicic acid be taken, like that corresponding to the proportion 1 : 3 : 4½, a completely crystalline mass is obtained, which bears in its optical

characters the same resemblance to hexagonal nepheline as chalcedony does to quartz. By melting together one-tenth pyroxene and nine-tenths nepheline a mixture of four different minerals was obtained: nepheline, pale green spinel, garnet in brown-yellow octahedra, and microlite. Leucite was also found in the fused product, and resembled both in form and optical characters the natural mineral.—(*Compt. rend.* lxxxvii. 961.)

The Supposed Native Iron of Greenland.—The Academy of Sciences of Paris appointed a commission to report on a paper by Dr. L. Smith on the "Supposed Native Iron of Greenland," and their report has recently been presented by M. Daubrée. It is pointed out that the bodies which come from beyond our atmosphere, and which are called meteorites, present as regards their mineralogical constitution a most striking resemblance to certain terrestrial rocks. The important fact that masses derived from most widely separated regions of space should present such resemblance was pointed out by Nordenskjöld in 1870, when he discovered large masses of native iron at Ovifak, on the Island of Disco. The first thought which suggested itself to him was that they were of meteoric origin. In order to explain the fact that these masses were forced into the basalt, he assumed that they had fallen into it while it was still liquid. Many adopted this view, and among others Nauckhoff and Tschermak. Steenstrup, on the other hand, after visiting the locality twice, came to the conclusion that they were masses of native iron, and that they had the same terrestrial origin as the basalt itself. Not far from Ovifak in the Waigatstrasse, Steenstrup found evidence which supported his theory: in the basalt of Igdlokungoak he hit upon a large mass of nickeliferous magnetic pyrites weighing about 28,000 kilogrammes, and again in the basalt of Aussuk small grains of native iron. The graphite associated with this iron pointed to the probability that carbonaceous substances had reduced this metal; moreover the rock enclosing the native iron also contained some of the ferric hydrated silicate which has received the name of hisingerite. With these opposing views, so plainly set forth, Dr. L. Smith has gone over the whole question, and comes to the same conclusion as Steenstrup, that the masses of metal are of terrestrial origin. He finds that in the dolerite of Aussuk, as well as that of Ovifak which it closely resembles, metallic iron is found enclosed in labradorite; anorthite is likewise found in certain parts of the mass of the rock and oligoclase also. Iron has been obtained from seven localities in Greenland: from Sowallicke, Fiskenäs, Niakornak, Glück's Bay, Jacobshavn, Ovifak, and Aussuk. The irons of Sowallicke and Niakornak are found by Dr. L. Smith to contain combined carbon just as the Ovifak iron does; in fact, he states that all specimens of iron obtained from Greenland are similar in this respect, and differ from meteoric iron which contains no combined carbon; moreover these masses all contain cobalt in considerable quantity in relation to the nickel. Dr. Smith next refers to the similar geological character of the area where the irons have been met with, it being found only in the basalt region, which extends from 69° to 76° where it disappears under a large glacier. We shall probably never know how wide the extent is of this volcanic area which stretches far away north; that, however, which has been seen represents an area equal to one extending from Gibraltar to Brest. We know that the rocks which present the greatest resemblance to

the meteoric rocks belong to the lowest beds of the earth. Some are eruptive rocks of basic character consisting of anorthite and augite, like certain lavas from Iceland; others are olivinous rocks, like lherzolite, to which the meteorites containing magnesia—those, in fact, of the ordinary type—belong. The presence of olivinous rocks accompanying the platinum of the Urals, and the presence of nickel in the iron combined with platinum, have confirmed these relations, which are of interest to both the geologist and the astronomer. It was expected that among the aluminous and magnesian rocks some might be found in which iron should begin to make its appearance, and this gap has now been filled. In the Greenland beds layers of lignite are found associated with the basalt, and this may have furnished the material which has reduced the iron to the metallic state.—(*Compt. rend.* lxxxvii. 911.)

Fairfield County Minerals.—G. J. Brush and E. S. Dana have published a second paper on the minerals of Fairfield County, Connecticut, in the "American Journal of Science," May, 1879. In the present paper they describe a new mineral which they name *fairfieldite.* It occurs in massive crystalline aggregates, rarely in distinct crystals. It has a hardness 3·5, and the specific gravity 3·25, a subadamantine lustre, and is white or of a pale straw colour. The streak is white and the substance itself transparent. It occurs in small particles in fillowite (described beyond) and in masses of some size immediately associated with eosphorite, triploidite, and dickinsonite. The crystals belong to the triclinic system. The analyses closely accorded with the numbers:

Phosphoric acid	39·30
Iron protoxide	6·64
Manganese protoxide	13·10
Lime	30·99
Water	9·97
	100·00

which correspond with the formula $3RO,P_2O_5,H_2O$, where $R = Ca : Mn + Fe = 2 : 1$, and the ratio of $Mn : Fe$ is also $2 : 1$. Fillowite occurs in granular crystalline masses which are not unfrequently penetrated by distinct prismatic crystals of triploidite, and sometimes enclose particles of fairfieldite. Reddingite is very commonly associated with fillowite, and in many cases it is not easy to distinguish the two minerals. The hardness is 4·5, and the specific gravity 3·41–45. The lustre is subresinous to greasy; the colour generally wax-yellow, also yellowish to reddish-brown, with a red or green tinge, and rarely almost colourless. The crystals have a marked rhombohedral aspect; the measurements, however, point to a monoclinic form, and that this is the true explanation was proved by the subsequent optical examination. The results of the analyses of this mineral nearly accord with the numbers given below:

Phosphoric acid	40·19
Iron protoxide	6·80
Manganese protoxide	40·19
Lime	5·28
Soda	5·84
Water	1·70
	100·00

which are those corresponding with the formula $3R_3P_2O_8 + H_2O$, if in this formula $R = Mn : Fe : Ca : Na = 6 : 1 : 1 : 1$. A small amount of water was met with even in the most transparent specimens. If the water were not essential, the composition of the mineral would be somewhat analogous to that of triphyllite, containing sodium in place of lithium.

A Titaniferous Chrysolite.—M. Damour [has] described a titaniferous chrysolite from Zermatt, Switzerland. (*Bull. Soc. Min. Franc.*, ii. 15.) It has a red colour similar to that of almandine garnet, and the specific gravity 3·27. Analysis shows it to consist of silicic acid 36·14; titanic acid 6·10; magnesia 48·31; iron protoxide 6·89; manganese oxide 0·19; and loss by ignition 2·23. Total = 99·86. This gives almost exactly the required ratio 1 : 1 for bases to silicon.

PHYSICS.

Rotation of the Plane of Polarization by Electro-Magnetism in a Vapour. MM. Kundt and Rontgen have communicated their results on this subject to the Munich Academy. They have proved the fact of such rotation, which Faraday failed in demonstrating, at least in the vapour of sulphide of carbon. This substance was chosen for experiment because it shows strong electro-magnetic rotation in the liquid state, and because its vapour has great tension, even at moderate temperatures. An iron tube, closed at the ends by thick glass plates, was enclosed in an outer tin tube through which steam at 100° Cent. could be passed. The outer tube was surrounded by six large coils of wire, containing 400 turns of thick wire each, through which a current from 64 large Bunsen elements was passed. Sulphide of carbon vapour was heated as above described, and at the temperature of boiling water the vapour became transparent. A beam of polarized light was passed through the tube, and analysed by Nicol's prism. On the current being sent, a distinct brightening of the field was observed, which increased if, after rotating the prism afresh to darkness, the current was reversed. The rotation was in the direction of the positive current through the coils, and amounted to about half a degree. Sulphuric ether similarly treated gave no result. The authors of the paper are making apparatus by means of which to examine permanent gases and unsaturated vapours, with the special view of ascertaining whether oxygen rotates the plane of polarization in the same direction as other gases. Monsieur E. Bichat contributes a memoir to the "Comptes Rendus" of the Academy, in which he states that he has been following out a similar series of experiments since July 1878, which give very different results from those noted above. He points out that the iron tube used by the German physicists very materially injures the completeness of the action. It is in reality a hollow electro-magnet; whereas his tube being of brass allows the whole force of the current to expend itself on the contained vapour. In illustration of the difference, he passes a tube containing liquid bisulphide of carbon through the two poles of an electro-magnet, obtaining a rotation of 10° 30′; but on using a single hollow core with the same current, no appreciable rotation is obtained. If the iron tube be thin, the action is not entirely annulled, but

is considerably diminished—in the instance he gives from 5° to 1°. With his apparatus he has followed from zero to boiling point the rotation of the same current in sulphide of carbon and bichloride of tin. The molecular rotatory power is maintained as long as the boiling point is not approached. At that moment there is a diminution much more rapid than could have been foreseen from calculations based on the ratios of density.

A Mirror Barometer.—M. Leon Tesserenc de Bort has ingeniously modified the common aneroid barometer by substituting for the train of clock-work terminating in a pointer a mirror mounted on a jewelled axis, which is rotated by the rise and fall of the exhausted receiver, and its indications read off by a small telescope by reflection from a graduated scale. The sensibility of the instrument is said to be much increased, and all errors due to a long train of wheelwork are eliminated.

Influence of Electricity on Colliding Water Drops.—Lord Rayleigh communicates a paper to the Royal Society on this subject. It has been long known that electricity has great influence on fine jets of water ascending in a nearly vertical direction. In its normal state a jet resolves itself into drops, which even before passing the summit of the column, and still more after passing it, are scattered to a considerable width. When a feebly electrified body is brought into the neighbourhood of the jet, it undergoes a remarkable transformation, and appears to become coherent; under more powerful electrical action the scattering becomes more marked than at first. The latter action is due to mutual repulsion of the drops; the former has been hitherto unexplained. The cohesion seems to be more apparent than real; the seat of sensitiveness is at the place of resolution into drops: each drop carries away with it an electric charge, which can be collected in an insulated receiver. He is able to show that the normal scattering is due to the rebound of the colliding drops; such collisions being inevitable in consequence of the different velocities acquired by the drops under the action of capillary force, as they break away irregularly from the continuous portion of the jet. When the resolution is regularized by the action of external vibrations, as in Savart's and Plateau's experiments, the drops must still come into contact as they reach the summit of their parabolic path. Under moderate electrical influence, instead of rebounding after collision, they coalesce, and the jet is not scattered. This behaviour of the drops becomes apparent under instantaneous illumination, such as that of an induction coil, into the secondary circuit of which a Leyden jar is introduced. To obtain further evidence two similar jets were made to collide horizontally, one being in communication with the earth, the other supplied from an insulated cistern. The sensitiveness to electricity was extraordinary. A piece of rubbed gutta-percha brought near the insulated bottle at once determined coalescence. It was also possible to cause the jets again to rebound from one another, and then to coalesce.

Besides statical electricity, the electro-motive force of a single Grove cell was sufficient to produce the same phenomena, one pole being connected with the water, the other to earth. Even the discharge of a condenser charged by a single Grove cell answered the purpose. The writer indicates in conclusion the probable application to meteorology of the facts mentioned. The formation of rain must obviously depend materially on the consequences

of encounters between cloud-particles. If the contacts result in coalescence the drops must rapidly increase in size and be precipitated as rain. We may thus anticipate an explanation of the remarkable but hitherto mysterious connection between rain and electrical manifestations.

Influence of Pressure on Spectra.—Herr Ciamician has contributed experiments on this subject to the Vienna Academy. The spectra of chlorine, bromine, and iodine show the same peculiarities under increased pressure; the bright lines becoming broader, but not spreading into bands, a continuous illuminated background appears which often overpowers the lines. The spectrum of sulphur does not change at all, neither does that of phosphorus and arsenic.

Metals behave very differently. Here a real band-like extension of the spectral lines takes place, while the continuous light remains subdued. In the mercury spectrum the enlargement of the green and violet lines is specially noteworthy. In the sodium spectrum the enlargement is very considerable, but can only be observed with the reversed or dark D line. Under high pressure sodium gives a continuous background in the immediate neighbourhood of the D line upon which the reversed line appears. The double line gradually merges into one, becoming wider until it finally covers the whole background.

The Induction Balance and Sonometer.—Professor Hughes read a most important paper on these remarkable instruments before the Royal Society on May 15. After noticing Arago's original discovery of the action of rotating plates upon a magnetic needle, as well as Babbage's, Herschel's, and Dove's experiments, he remarked that in the microphone and telephone an instrument of extreme sensitiveness to minute induced currents had been obtained, and already published by him. In continuing the inquiry, the idea occurred to him that he might again investigate the molecular constructions of metals and alloys; and with this object has obtained, after numerous comparative failures, a perfect induction balance, which is not only exquisitely sensitive and exact, but allows us to obtain direct comparative measures of the force or disturbances produced by the introduction of any metal or conductor.

The instrument presented to the Royal Society consisted—1st, of new induction-currents balance; 2nd, microphone, with a clock as a source of sound; 3rd, electric sonometer, or absolute sound measurer; 4th, a receiving telephone and three elements of Daniells' battery.

In order to have a perfect induction-currents balance suitable for physical research, all its coils, as well as the size and amount of wire, should be equal. The primary and secondary coils should be separate, and not superposed. The exterior diameter of the coils is 5½ centims., having an interior vacant circular space of 3½ centims.; the depth of the flat coil or spool is 7 millims.

Upon this box-wood spool are wound 100 metres of No. 32 silk-covered copper wire. Four of such coils, formed into two pairs, are used, the secondary coil being fixed permanently, or by means of an adjustable slide, at a distance of 5 millims. from its primary; on the second similar pair there is a fine micrometer screw, allowing the adjustment of the balance to the degree of perfection required.

These two pairs of coils should be placed at a distance not less than 1 metre from each other, so that no disturbing cause should exist from their proximity.

The two primary coils are joined in series to the battery, the circuit also passing through the microphone.

The telephone is well adapted as an indicator, but not as a measurer of the forces brought into action. For this reason he has joined to this instrument an instrument to which he has given the name of electric sonometer. This consists of three coils, similar to those already described, two of which are placed horizontally at a fixed distance of 40 centims. apart, and the communication with the battery is so arranged that there are similar but opposing poles in each coil; between these there is a coil, which can be moved on a marked sliding scale divided into millimetres, in a line with these two opposing primary coils; the centre coil is the secondary one, and connected by means of a circuit changing key with the telephone in place of the induction balance. If this secondary coil is near either primary coil, we hear loud tones, due to its proximity. The same effect takes place if the secondary coil is near the opposing coil, except that the induced current is now in a contrary direction, as a similar pole of the primary acts now on the opposite side of the induction coil; the consequence is, that as we withdraw it from one coil approaching the other, we must pass a line of absolute zero, where no current whatever can be induced, owing to the absolute equal forces acting equally on both sides of the induction coil. This point is in the exact centre between the two coils, no matter how near or distant they may be. We thus possess a sonometer having an absolute zero of sound; each degree that it is moved is accompanied by its relative degree of increase; and this measure may be expressed in the degrees of the millimetres passed through, or by the square of the distances in accordance with the curve of electro-magnetic action.

If we place in the coils of the induction balance a piece of metal, say copper, bismuth, or iron, we at once produce a disturbance of the balance, and it will give out sounds more or less intense on the telephone according to the mass, or if of similar sizes, according to the molecular structure of the metal. The volume and intensity of sound is invariably the same for a similar metal. If by means of the switching key the telephone is instantly transferred to the sonometer, and if its coil be at zero, we should hear sounds when the key is up or in connection with the induction balance, and no sounds or silence when the key is down or in connection with the sonometer. If the sonometer coil were moved through several degrees, or through more than the required amount, we should find that the sounds increase when the key is depressed; but when the coil is moved to a degree where there is absolute equality with the key up or down, then the degree on scale should give the true value of the disturbance produced in the induction balance; and this is so exact that if we put, say, a silver coin whose value is 115°, no other degree will produce equality. Once knowing, therefore, the value of any metal or alloy, it is not necessary to know in advance what the metal is, for if its equality is 115°, it is silver coin; if 52, iron; if 40, lead; if 10, bismuth; and as there is a very wide limit between each metal, the reading of the value of each is very rapid, a few seconds sufficing to give the exact sound value of any metal or alloy.

The Audiometer was exhibited by Dr. Richardson at the meeting of the Royal Society on May 22. It consists of two Leclanché's cells; a new microphonic key connected with the cells, and with two fixed primary coils; and a secondary or induction coil, the terminals of which are attached to a telephone. The induction coil moves on a bar between the two fixed coils, which is graduated into 200 parts, by which the readings of sound are taken. The scale is divided into 20 centims., and each part is subdivided into 10, so that hearing may be tested from zero to 200. The fixed coil on the right hand contains 6 metres of wire; that on the left hand contains 100 metres. The secondary coil contains 100 metres of wire.

In using the instrument, the induction coil is moved along the scale from or towards the larger primary as may be required, and the degrees or units of sound are read from the scale, the sound being produced by the movement of the microphonic key between the battery and the primary coils.

As a rule, the hearing of right-handed persons is most refined in the right ear. The influence of atmospheric pressure is to be detected by this instrument, the delicacy of hearing diminishing when the barometer is low. The effect of practice and of memory in distinguishing sounds has also been experimented on.

The Sphygmophone.—It occurred to Dr. B. W. Richardson, while experimenting with the audiometer, that he might get a secondary or telephonic sound from the movements of the pulse at the wrist. He effected this in a very simple manner, by adding a microphone to a Pond's sphymograph. He mounts on a slip of talc a thin plate of platinum, and places the talc slip in the sphygmograph as if about to take a tracing of the pulse. He connects one terminal from a Leclanché's cell to the slip of platinum on the talc, and the second terminal from the cell to a terminal of the telephone. Then he connects the other terminal of the telephone with the metal rod of the sphygmograph which supports the talc. The instrument is now ready for use. It is placed on the pulse in the ordinary way, and is adjusted, with the writing needle thrown back, until a good pulsating movement of the needle is secured. When the movement is in full action, the needle is thrown over to touch the platinum plate, which it traverses with each pulse-movement and completes the connection between the telephone and the battery. The needle, in passing over the metallic plate, causes a distinct series of sounds from the telephone, which correspond with the movements of the pulse. When all is neatly adjusted, the sounds heard are three in number, one long sound and two short, corresponding to the systolic push, the arterial recoil, and the valvular check. The sounds are singular, as resembling the two words "bother it." The sounds can be made very loud by increasing the battery power. This little instrument is not so good a recorder of the pulse as the sphygmograph, but it may be made very useful in a class, for illustrating to a large number of students, at one time, the movements of the natural pulse, and the variations which occur in disease.

PHYSIOLOGY.

The Secretion of the Gastric Glands.—Professor Heidenhain succeeded in separating a considerable portion of the fundus of the stomach in a dog from its connection with the rest of the organ, and forming it into a blind sac communicating with the exterior of the body. This enabled him to collect the secretion of the gastric glands unmixed with that of the pyloric glands, and uncontaminated by the saliva and other liquids which pass down the œsophagus. The secretion is a clear, strongly acid liquid, containing an unexpectedly small amount of mucus, and an average of 0·45 per cent. of solid matter, partly organic, partly inorganic, the former consisting mainly of pepsine. The average acidity of the liquid is equivalent to 0·52 per cent. of hydrochloric acid, which is far higher than that of the mixed gastric juice, free from saliva, examined by Bidder and Schmidt. Richet, from observations on the juice of a man with a gastric fistula, found that when fresh it contained only hydrochloric acid, while when kept for a time it developed an organic acid, probably sarcolactic. No such acid was observed to be produced in the secretion obtained from the dog. It was found that the introduction of nutritious food into the stomach induced active secretion in from fifteen to thirty minutes, and this continued until the stomach had completely emptied itself. But if indigestible substances were introduced no secretion flowed from the sac for upwards of an hour. Water was then given to the animal, and secretion commenced, but only lasted an hour and a half. From these and other experiments, Professor Heidenhain concludes that mechanical stimulation of the stomach excites secretion only at the point of contact; general activity of the glandular apparatus requiring absorption for its production. If the composition of the secreted liquid be examined at regular intervals during the digestive process, its acidity is found to remain pretty uniform, but the proportion of pepsine contained in it undergoes a peculiar and orderly series of variations. During the second hour it sinks rapidly to a minimum; towards the fourth or fifth hour it rises again to a point generally higher than at first, and remains at or near this point for a considerable time. These variations are quite independent of the amount of pepsine actually contained in the glands which is known to sink steadily. The secreting surface can pour out a liquid very rich in pepsine at a time when its poverty in this substance is most strongly marked. No definite conclusion can at present be arrived at as to the cause of this phenomenon. (*Pflüger's Archiv.*, vol. xix.; *Academy*, April 26, 1878.)

ZOOLOGY.

The Bovidæ.—M. A. Sanson has communicated to the French Academy of Sciences a note on the results of his researches upon the fossil or ancient remains of Bovidæ and their relationships to existing forms, which are of some interest.

He finds that the Aurochs of Cuvier, *Bos urus* of Bojanus, *B. priscus*, Allen, *B. latifrons*, Harlan, and *B. antiquus*, Leidy, are all Bisons which

do not differ specifically from the existing *B. americanus* and *B. europæus*. They are at the utmost varieties of the same species.

Bos primigenius, Bojanus, is still represented by a numerous race, varieties of which occupy the ground between the *embouchures* of the Loire and Gironde, extending towards the south-east as far as Mont Aubrac. To this form M. Sanson gives the name of *Bos taurus ligeriensis*.

Bos trachoceras, Meyer, and *B. frontosus*, Nilsson, belong to a single species, M. Sanson's *B. taurus jurassicus*. This race, which is constantly extending, at present inhabits the cantons of Berne and Fribourg in Switzerland, and La Bresse and the valley of the Saône, is spreading more and more into the districts of Le Nièvre, Cher, and Allier in France, and is also disseminated in Germany, Austria, and Italy. It is one of the types found in the Lake-dwellings.

Bos longifrons, Owen, is an ancient representative of the existing *Bos taurus bataricus*. Its remains have never been found outside of the natural geographical area of the latter, included in the basin of the North Sea, and extending into England, Holland, Belgium, and the north of France and Germany. The craniological type of this race has most clearly defined characters, so that it is difficult to understand how it can ever have been confounded with that of *Bos primigenius*.

Bos brachyceras, Rütimeyer, survives in the *Braunvieh* of Switzerland, named by M. Sanson *Bos taurus alpinus*, as it inhabits the region of the Alps, where it has formed numerous varieties.

Bos brachycephalus, Wilcken, remains of which are found in the peat of Laibach, is supposed by its describer to be derived from the European Bison. It is identified by him with a race existing in Tyrol, which was formerly regarded as a hybrid of *Bos frontosus* and *B. brachyceras*. This is regarded by M. Sanson as its most probable origin.

Sulphuret of Carbon for Killing Insects.—Dr. J. M. Eder proposes the use of a sulphuret of carbon bottle for killing insects in place of the cyanide of potassium bottle which is now so commonly employed. He describes it as particularly well adapted for beetles. The apparatus recommended is a wide-mouthed bottle, well-corked, containing a few fragments of blotting-paper. When an insect is captured and put into the bottle it is to be followed by three or four drops of sulphuret of carbon (a supply of which must be carried in a small store-bottle), when the animal is almost instantaneously killed by the action of the vapour produced. The largest beetles die in a few seconds. With careful corking after the introduction of each capture, the three or four drops of sulphuret of carbon will continue their action for an hour or two, but as soon as the insects begin to die slowly, a fresh supply of the reagent must be added. The great advantage is that owing to the rapidity with which sulphuret of carbon evaporates, the interior of the vessel is always perfectly dry, so that no insect, however delicate, can be injured by it. Solution of cyanide of potassium is said to be slower in its action, and to have the disadvantage of introducing moisture, and of giving origin to carbonate of potash, a hygroscopic salt.—(*Verhandl. Zool. bot. Gesellsch. in Wien*, 1878.)

Sounds produced by Fishes.—M. W. Sörensen, during a residence at the mouth of the Riacho del Oro (Paraguay), had the opportunity of investigat-

ing the mode in which certain fishes of the rivers in that region, especially Siluroids and Characini, are enabled to emit sounds. The organ implicated in this phenomenon is, according to him, the air-bladder, which is peculiarly modified. In the Siluroids, the unossified part of the air-bladder is elastic throughout, whilst in the Characini the elasticity chiefly depends upon flat bands or round cords situated in the wall. In the Siluroid genera *Platystoma* and *Pseudaroides*, the air-bladder is divided by a longitudinal partition and by several transverse ones into a number of chambers which, however, still communicate with each other. In *Doras*, it has numerous appendages divided by imperfect septa into a great many small cells. In all these fishes the transverse processes of the two or three first vertebræ, and often a part of the arch of the first vertebra, are bound together and to the hinder part of the skull by strong elastic membranes. The transverse processes of the first or second vertebræ, and sometimes of both, are formed into powerful springs and closely bound to the air-bladder. The sound is produced by the action of muscles inserted, either directly upon the air-bladder, or upon the transverse process of the third vertebra. In the Characini, the elastic parts of the air-bladder are stretched lengthwise by the contraction of the muscles, and the vibration produced by this movement is transmitted to the air contained in the cavity of the bladder. In the Siluroids the forepart of the air-bladder is drawn alternately forward and backward by the contraction and relaxation of the muscles, and the air passing by the imperfect transverse partitions sets these in motion and causes the sounds.—(*Comptes rendus*, May 19, 1879.)

Trichinæ in the Hippopotamus.—M. E. Heckel announces the occurrence of *Trichinæ* in great abundance in a young hippopotamus received from Egypt, which lived for about four months in the Zoological Gardens at Marseilles. The animal suffered from skin disease, taking the form of great suppurating boils, during the whole of its residence at Marseilles. On examination these sores were found to have penetrated the skin, and to lead to great cysts filled with pus in the subcutaneous tissue. It was after the greater part of the flesh had been thrown away that M. Heckel detected the *Trichinæ* in the muscles surrounding one of the cysts which he had kept, and he was unable to ascertain whether the trichinosis and the external symptoms were in any way correlated. The discovery of the parasite in this great Pachyderm is of interest.—(*Comptes rendus*, June 2, 1879.)

Metamorphoses of the Blister-Beetles.—The transformations of the common blister-beetle, or so-called Spanish fly of the shops (*Lytta vesicatoria*) have eluded the researches of entomologists, although the insect itself is exceedingly abundant on ashes and other trees in the south of Europe. The life-history of other species of the same family (*Meloë*, *Sitaris*, *Epicauta*) has, however, been worked out, and entomologists will be glad to learn that M. Lichtenstein, guided by the results obtained in the investigation of those forms, has at last succeeded in solving the problem and demonstrating that the stages through which the officinal blister-beetle passes are very similar to those presented by its nearest relatives.

At the end of May, or the beginning of June, the females deposit their eggs in small excavations in the ground; the eggs are elongated, whitish, and transparent, and each female lays several hundred of them in a small

mass. They hatch in a fortnight, and the larva produced is, as in the case of the other genera, a "Triungulinus," a little, active, three-clawed creature, originally detected upon bees, and described as a special parasite, before its connection with these beetles was known. The Triungulinus of the blister-beetle is dark brown, with a white band across the middle of its body; its eyes are black and prominent, and its jaws very sharp, and it has two long caudal bristles. M. Lichtenstein had some difficulty in getting the young animals to feed, but at last he tempted them with the stomachs of honey-bees, and then gave them the eggs and young larvæ of various species of bees. But he found that it was necessary to associate honey with their animal food, otherwise they would not touch the latter, almost as if they were instinctively aware that honey would be absolutely requisite for their sustenance as soon as they had undergone their first change of skin. When this condition is fulfilled, however, he found that they at once inserted their jaws into the egg or larva before them, and increased rapidly in size. In five or six days they changed their skin, and gave origin to small, white, six-footed larvæ, without caudal bristles, and with blunt jaws; these quitted the animal food and devoted themselves to the honey. In five days more there was another change of skin; after which the jaws were still broader and the eyes less marked; and after the next change, which took place five days later, the eyes had disappeared, the legs and jaws had become brown and horny at the end, and the larva had the appearance of a small grub of a Lamellicorn beetle. This form is called by Mr. Riley the "Scarabæoid larva," and it was apparently fitted for burrowing. Accordingly the insects in this stage were transferred to a new form of prison, in which they had a sufficient quantity of damp earth in which to bury themselves, which they proceeded to do at once, making their way nearly to the bottom of the earth in their tubes, and resting in a small cavity close to the wall of the tube, thus enabling the author to observe their subsequent proceedings. After remaining here for another five days they underwent a fresh change, and gave origin to a pupa-like creature, having four little tubercles at the anterior end, and three pairs of tubercles at the points where the legs had been situated. In this state they remained motionless through the winter, but on April 15 they burst their envelope, and produced, not a perfect beetle, but a white, grub-like creature, with rudimentary feet, and in other respects somewhat resembling the larva which had burrowed down into the ground. In this condition the insect moved slowly in its cell, but ate nothing, until in about a fortnight, it again cast its skin and gave birth to a pupa, presenting all the characters of those of beetles. At first white, the pupa speedily became coloured; on May 17 it was quite of a dark tint, and on the 19th the perfect beetle was seen in its retreat ready to emerge. The development had thus occupied just a year. M. Lichtenstein believes that the burrowing bees, such as the *Halicti* and *Andrenæ*, are those at whose expense the blister-beetle is nourished.—(*Comptes rendus*, May 20, 1879.)

The Gall-Aphides of the Elm.—Dr. Riley has ascertained that the natural history of the aphides which produce galls deforming the leaves of the common American Elm is exceedingly complicated. The species described by him is *Schizoneura americana*. During the winter, in the cracks in the bark of an elm, the leaves of which suffered much from the attacks of the

aphides the preceding summer, the eggs may be found, often still covered by the dried skin of the mother. The eggs are of a dull-yellow colour, and about $\frac{1}{50}$ inch long. Early in the spring these eggs give birth to a little crawling insect which proceeds to attack the young tender leaves, on which it feeds, causing the leaf to pucker until it at last curls into a protective shelter for the so-called "stem-mother." After three months the latter begin to people the leaf with viviparously produced young at the rate of about one every six or seven hours. The second generation resemble their parent in many respects, but none grow so large; they accumulate in immense numbers, and some of them, crawling away, form new colonies on other leaves. They produce the third generation, which is destined to acquire wings, and the individuals forming it, which are short-lived, deposit twelve or more "pseudova" at intervals of about half-an-hour. The young aphides, issuing from these, and constituting the fourth generation, are very active and move swiftly. They are of a brown colour, and in general appearance somewhat like those of the second generation. In this stage they swarm over every part of the tree, and their necessities often cause them to migrate, during which process great quantities of them are destroyed. The fifth generation is very similar to the fourth, but without wings. The aphides of the sixth generation all acquire wings. They abound in the latter end of June and the early part of July. They congregate on the bark, seeking out sheltered cracks and crevices in which they deposit their young, forming the seventh generation, which are sluggish and of the colour of the bark, the females being a little larger than the males. They have no mouth, but live motionless for a few days, during which the female seems to increase in size by the enlargement of her single egg. Both sexes soon perish, leaving among their shrivelled bodies the shining, brownish winter-egg from which this series of generations started; so that, as Dr. Riley says, after a long series of vegetative (agamic) reproductions, at last the time comes for the renewing of the race by this zygospore-like body.—(*Journ. Roy. Micr. Soc.*, June, 1879.)

A Supposed New Order of Crustacea.—In the February number of the *American Naturalist*, Dr. A. S. Packard, jun., observes that the *Nebaliadæ*, represented by the existing genus Nebalia, have generally been considered to form a family of the Phyllopod Crustacea; Metschnikoff, who studied the embryology of *Nebalia*, considering it to be a "Phyllopodiform Decapod." But besides the resemblance to the Decapods there is also a combination of Copepod and Phyllopod characteristics. The type, he points out, is an instance of a synthetic one, and is of high antiquity, having been ushered in during the earliest Silurian period, when there were (if we regard the relative size of most Crustacea, and especially of the living *Nebaliæ*) gigantic forms. Such was *Dithyrocaris*, which must have been over a foot long, the carapace being seven inches long. The modern Nebalia is small, about half-an-inch in length, with the body compressed, the carapace bivalved, as in *Limnadia*, one of the genuine Phyllopods. There is a large rostrum overhanging the head; stalked eyes, and besides two pairs of antennæ and mouth-parts, eight pairs of leaf-like, short, respiratory feet, which are succeeded by swimming feet. There is no metamorphosis, development being direct.

Of the fossil forms, *Hymenocaris* was regarded by Salter as "the more generalized type." The genera *Peltocaris* and *Discinocaris* characterize the lower Silurian period, *Ceratiocaris* of the upper, *Dictyocaris* the upper Silurian and the lowest Devonian strata, *Dithyrocaris* and *Argas* the Carboniferous period. Our existing north-eastern species is *Nebalia bipes* (Fabr.), which occurs from Maine to Greenland.

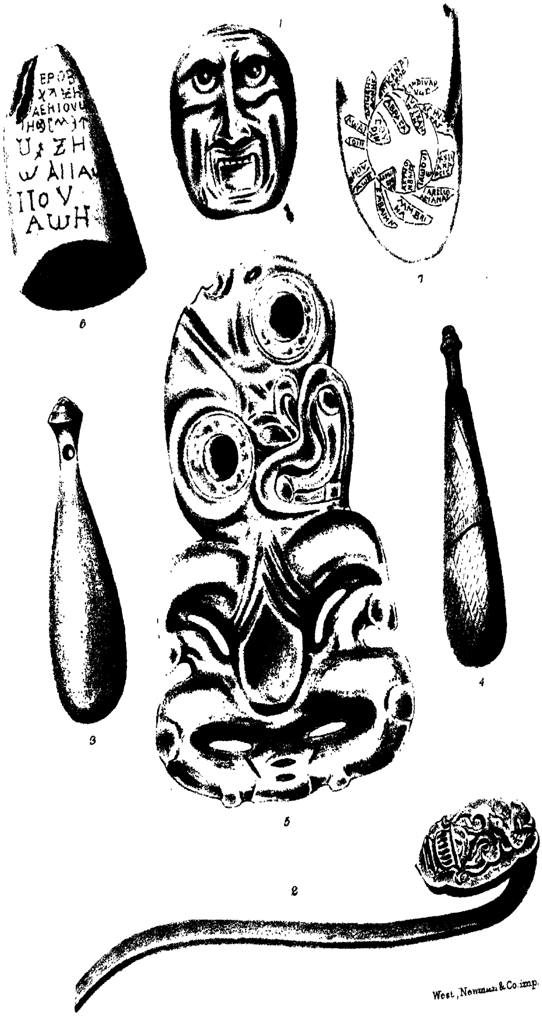
The Nebaliads were the forerunners of the Decapoda, and form, Dr. Packard believes, the type of a distinct order of Crustacea, for which he proposes the name of Phyllocarida.

A Segmental Organ in the Endoproct Bryozoa.—In the *Comptes Rendus* of February 24, 1869, M. L. Joliet brings forward evidence in support of the observations of Hatschek, who, in October 1877, indicated in *Pedicellina echinata*, both in the larval and adult state, a vibratile canal, of which, however, he did not appear to have well made out the form, and which he compared to the vibratile organs of the Rotatoria. M. Joliet states that he is now in a position to confirm, correct, and complete the statements of Hatschek, and to extend them to the whole group of Endoproct Bryozoa.

In a spineless variety of *Pedicellina echinata* which he examined, the vibratile organ was double, and situated in the cavity of the body, in the space included between the œsophagus, the stomach, and the matrix. It consisted of a short tube, ciliated internally, inflated at its middle, which, on the one hand, opened into the matrix, not far from its external aperture, and, on the other, opened obliquely into the cavity of the body by a slightly funnel-shaped passage furnished with active vibratile cilia. This organ, furnished with a vibratile pavilion, and placing the cavity of the body in communication with the outer world, had all the characters of a segmental organ. It appears very early in the bud; and when the stomach is only sketched out, and before the arms are indicated, a ciliary movement is already perceptible at the place that it will occupy.

In a still undescribed species of *Pedicellina* from the island of St. Paul, M. Joliet has also detected the same vibratile organ; and still later, in the *Loxosoma* of *Phascolosoma*, he recognized a perfectly similar canal, terminated by a pavilion and placed in the same situation. As in *Pedicellina*, it appears very early in the bud.

M. Joliet therefore concludes that in the group Endoprocta, including the highest forms of the Bryozoa, the presence of a segmental organ (that is to say, an organ which is very generally diffused among the Vermes) may be regarded as constant; and considering the endeavours that have been made of late years to approximate the Bryozoa to the Annulata, he thought it an advantage to bring this new argument into the debate, as possessing considerable value.



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WORKED JADE & JADEITE.

ON JADE AND KINDRED STONES.

BY F. W. RUDLER, F.G.S.

[PLATE VIII.]

SCIENCE is unquestionably the arch-foe to superstition; yet superstition, it must be conceded, has unwittingly rendered an occasional service to the cause of science. How ill, for instance, might it have fared to-day with the student of pre-historic archæology if our ancestors had been free from any superstitious regard for those implements of stone—unknown alike in origin and use—which they occasionally brought to light with help of spade and plough! As long as the flint arrow-head was regarded as a "fairy dart," or the stone axe as a "thunderbolt," it stood in little danger of being heedlessly destroyed. Shielded by the supernatural origin to which it was referred, the relic may have been piously preserved, generation after generation, until in these latter days it has come to grace the cabinet of an archæologist. The time of real danger was not when there was too much superstition abroad, but when there was too little superstition, yet not sufficient science—when men had ceased to value a stone implement as talisman, or amulet, or charm, but were not sufficiently enlightened to recognise its true meaning and to value it on scientific grounds.

Much of the esteem which the ancients set upon precious stones was due, in like manner, to the superstitions by which such minerals were liberally surrounded. No doubt the properties which we prize at the present day—such as colour, brilliancy, and hardness—were equally prized in the remotest times at which precious stones were used; but above and beyond these obvious characters, overarching all these physical properties, there was the higher value derived from their metaphysical virtues. Some of these virtues were of a purely spiritual character, such as the power attributed to so many gems of dispelling vicious propensities and of inspiring purity of life in the owner. Others, however, were of less subtle nature, and were in fact medicinal rather than metaphysical.

In order to cure disease, it was in most cases considered sufficient to simply wear the stone, when its sympathy with the affected part brought its curative power into play. But in other cases recourse was had to the grosser method of internally administering the powdered gem. These superstitions naturally led men to seek eagerly for stones so marvellously endowed, and thus our knowledge of such minerals and of their mode of occurrence became widened. Stones which were reputed to possess therapeutic virtue were carefully preserved and studied in their minutest details. Who indeed would not diligently seek and fondly cherish an object which was at once a personal ornament and a specific against disease?

It is curious to note how wide-spread are the superstitions which have clustered around stones of a green colour. Belief in their efficacy has been held by the peoples of the New World not less than by those of the Old; they are mentioned in the most ancient works on such subjects; their virtues are extolled by mediæval writers; and, indeed, it may be doubted whether the superstitions have yet died out. To take the emerald alone, a catalogue of its reputed virtues would run to inconvenient length. Soon after the discovery of America, the Spaniards brought to Europe some curious green stones which were held to be singularly efficacious in their medicinal properties. From the fact that the mineral was a specific for diseases of the kidneys, it was termed by the Spaniards *Piedra di hijada*, or "stone of the loins." By those who were ignorant of Spanish, the term was naturally corrupted; and it needs no philological aid to see how *hijada* or *ijada* might gradually become transformed into *jade*. The stone was also known as *Piedra de riñones*, or "stone of the kidneys," whence arose the term *Lapis nephriticus*, or *Pierre néphritique*, and finally the mineralogical designation *nephrite*, from *νεφρὸς*, *kidney*.

It appears that the earliest recorded reference to this green stone as *Piedra de hijada*, occurs in the work of a Spanish doctor, Nicolas Monardes, published in 1565.* In this work he gives an account of the medicinal products of the West Indies. The *materia medica* of a mediæval doctor included some extraordinary drugs, and the Spanish physician gives us a chapter *De la Piedra de Sangre y de la Piedra de la Yjada*, in other words, of the "bloodstone" and of the jade. Of the latter he says that the deepest green kind is the most prized, and that it is worked into various forms by the Indians, who wear the objects as amulets against diseases of the loins and of the stomach. So strong is the antagonism between the stone and the disease,

* "Historia Medicinal de las cosas, que se traen de las Indias occidentales, que siruen en Medicina."

that, by merely wearing a bracelet of jade, the fortunate possessor is kept free from any attack of such malady.

Among the many novelties which Sir Walter Raleigh introduced into this country, mention should be made of the jade-stone. Such at least is the testimony of Sir Hans Sloane, who refers to him when speaking of the hard green stone found as pebbles upon the shores of Jamaica. "This," says the naturalist, "is the *piedra hijada* of the Spaniards, and *Pierre de Jade* of the French authors, who magnify the virtues of it so as to make them incredible; nay, Mr. Labart, a French late author, would make us believe it cures epileptic fits. Sir Walter Raleigh first brought some of them to England, giving vast encomiums of them." *

Sir Hans Sloane describes this jade under the name of *Spleen-stone* or *Jasper viridis*. So close, indeed, is its resemblance to some kinds of green jasper that it was generally described by early authors under that name. For this reason, among others, there is considerable obscurity in the references of the older writers upon precious stones, and it is in many cases impossible to determine whether they mean jade, jasper, or some other dark green mineral. Those who care to thread their way through the maze of ancient and mediæval writers will find an able and sympathetic guide in Professor Fischer, of Freiburg-im-Baden, who, attacking the subject with Teutonic perseverance, has produced an exhaustive monograph on jade.†

From Nova Hispania the Spanish conquerors obtained some valuable green stones, among which jade was probably included. Curiously enough no jade is now known to occur in Mexico or in Central America, or indeed, anywhere on the American continent. Yet it seems beyond doubt that the mineral was employed in ancient Aztec art, and it appears to have been one of the stones to which the term *chalchihuitl* was applied.

The chalchihuitl is a stone which the old Spanish chroniclers are never tired of extolling. When Cortez landed at San Juan de Ulua, the first messengers sent by Montezuma brought with them "four chalchihuitls, a species of green stone of uncommon value, which is held in higher estimation with them than the smaragdus." So writes the chronicler Bernal Diaz, as translated by Lockhart. As a matter of course, supernatural powers were attributed to the stone; and indeed there is a legend which asserts that Quetzacoatl, the great lawgiver and high-priest of the ancient Mexicans, was begotten by a chalchihuitl placed in the bosom of the goddess Chimalma.

* "The Natural History of Jamaica," vol. ii. 1725, pp. 338, 339.

† "Nephrit und Jadeit, nach ihren mineralogischen Eigenschaften sowie nach ihrer urgeschichtlichen und ethnographischen Bedeutung." Stuttgart, 1875.

And what, after all, was this extraordinary stone—so wondrously endowed and so highly prized? This is a question which, in spite of all that has been written on the subject, has not yet, and perhaps never will be, answered with scientific accuracy. Some have described the chalchihuitl as a coarse emerald, others as a turquoise, others again as a jasper, and some finally as jade. Probably the term comprised a number of distinct minerals, having in common a green or greenish-blue colour, and including the jade-stone. Such at least seems to be the opinion of Mr. E. G. Squier, whose researches have thrown so much light upon American archæology.* That jade, or some kindred stone, was used by the ancient Mexicans seems certain from the specimens which have come down to us. Mr. Pumpelly, an American geologist, after describing a jade-like mineral from China, to which the name of *jadeite* is now given, goes on to say: "The chalchihuitl, a precious stone of the ancient Mexicans, as I have seen it in a mask preserved in the Museum of Practical Geology in London, and in several ornaments in the collection of Mr. Squier of New York, is apparently the same mineral." † The mask to which Mr. Pumpelly refers is figured in Plate VIII. fig. 1.

Since we are not aware that any jade, or jade-like mineral, occurs in Mexico, or as said before throughout America, it becomes an extremely interesting question to enquire whence the ancient inhabitants of Anahuac obtained their supply of the precious mineral. Did they procure it from the old world? If so, here is another link in the chain of evidence which points to early intercourse, at any rate to pre-Columbian communication, between the eastern and the western hemispheres. The home of the jade, so far as we know, is in the east rather than in the west; and the country in which it seems to have been longest used and most highly venerated is China.

By the Chinese, jade is generally known as *yu*; but it has been said that this is a generic name for a number of ornamental stones. Sometimes the word *chi* (or *stone*) is attached, and the jade is then referred to as *yu-chi*. Rémusat, whose *History of Khotan* was published in 1820,‡ discusses with great erudition the meaning of the word, and refers it to a very high antiquity. In the province of Yunnan, a particular kind of jade, to be hereafter noticed, is known as *fei-tsui*; while in Turkestan the jade-stone is called *yaschm*, a word which is

* "Observations on the Chalchihuitl of Mexico and Central America." By E. G. Squier, M.A. New York, 1869.

† "Geological Researches in China," etc. Smithsonian Contributions, 1866, p. 118.

‡ "Histoire de la Ville de Khotan, tirée des Annales de la Chine et traduite du Chinois."

also found in the form of *yeschl*, and is said to be cognate with *ἴασπις*, and therefore with our *jasper*. It has already been seen that jade was formerly regarded as a green jasper.

Jade is a stone of singular tenacity, breaking with difficulty and displaying a coarse splintery fracture. Notwithstanding the difficulty of cutting and polishing the stone, it has for ages been worked by the Chinese into a great variety of objects, such as vases, cups, armlets, bracelets, and other ornamental articles, often of most intricate patterns. These objects have always been very highly valued, on account not only of the beauty and rarity of the material, but also of the great amount of labour necessarily expended upon their production. This has led to numerous imitations of the Chinese yu-stone in glass or enamel known as *pâte de riz*.

It is said that when a piece of yu-stone of unusual size is discovered, the Emperor calls a council of artists to determine the form in which it may be most advantageously worked. On any important carving in jade the artist will spend at least twenty years, and in some cases his entire lifetime. When completed, the work is exposed to public criticism for a year, and if then pronounced satisfactory, the artist receives high honour and may be raised to the rank of a mandarin; but if the work is faulty he loses not only his reputation but his head.*

Probably the finest assemblage of objects ever made in yu, or Oriental jade, was the collection found at the Emperor of China's Summer Palace, Yuen-min-Yuen, at Pekin, when sacked in 1860. From this source a large number of specimens found their way to this country and to France. Some remarkable examples of jade-working may be seen in the South Kensington Museum, where there are two cases of fine carvings lent by Arthur Wells, Esq., of Nottingham. The colour of Oriental jade varies through a great variety of shades of green, but the stone is frequently of a milky white colour, very slightly tinged with a greenish yellow. While the white jade is generally uniform in tint, much of the green jade is mottled, or flecked with darker spots.

Among the more notable objects which the Chinese are fond of carving in yu-stone is the peculiar staff or wand of authority known as the *joo-ee*. One of these batons is represented in Pl. VIII. fig. 2. A joo-ee generally takes the form of a graceful double curve, something like the letter ∽, but with less pronounced curvature, and more like Hogarth's famous "line of beauty." It is only the finest of the joo-ees that are made of

* "Catalogue of Captain De Negroni's Collection of Chinese Porcelain, Jade," etc. 1865.

jade, others being carved in wood or in rock-crystal or even worked in metal. This instrument was formerly given by the Emperor to princes of state or to governors on taking official appointments, and was carried by them as an emblem of authority. It is now exchanged as a mark of friendship or expression of goodwill. The name signifies "As you wish," being a contraction of *Sze-sze-joo-ee*, or "everything according to your wish." The expanded end of a joo-ee generally bears a carving of the sacred lotus.*

Although jade is so highly prized in China, very little seems to be known about its occurrence in that Empire. It is said, however, that Chinese works on geography give a number of localities which have yielded the stone; and Mr. Pumpelly, whose work has previously been cited, describes the occurrence of a jade-like mineral—the jadeite of mineralogists—in the mountains of Southern Yunnan: the mineral is known locally as *fei-tsui*, and is "perhaps the most prized of all stones among the Chinese."

Whatever jade may be got in China itself, it is certain that the Chinese have relied for generations upon the quarries of Khotan for a large proportion of their raw material. As far back as 200 B.C., under the Han dynasty, the yu was regarded as the most costly production of Khotan. Marco Polo, who visited the country in the 13th century, refers to the occurrence of jasper and other ornamental stones between Yarkand and Khotan, whence he says they were imported into China.

Little, however, was known about the occurrence of jade in Turkestan until a few years ago, when the locality was visited by the brothers Schlagintweit—Hermann, Robert, and Adolph.† The quarries were afterwards described by the late Dr. Stoliczka, of the Geological Survey of India,‡ and by Dr. Cayley.§ We are now therefore in possession of accurate details as to the workings in this district—a district which has supplied the Chinese with more or less of their jade for the last two thousand years.

The old jade quarries are situated on the banks of the Karakash River, which flows down the southern slope of the

* "Catalogue of the Chinese Collection at Hyde Park Corner." By W. B. Langdon. 1844.

† "Ueber Nephrit nebst Jadeit und Saussurit in Künlün-Gebirge." Von Hermann von Schlagintweit-Sakünlünski. Sitzungsberichte der K. Bair. Akad. d. Wissensch, Munich, 1873, pp. 227–267.

‡ "On the occurrence of Jade in the Karakash Valley." "Quart. Journ. Geol. Soc.," vol. xxx. 1874, p. 568. "Rec. Geol. Surv. India," vol. vii. p. 51; and "Scientific Results of the Second Yarkand Mission," 1878, p. 18.

§ "The Jade Quarries of the Kuenlun": "Macmillan's Mag." vol. xxiv. 1871, p. 452.

Kuenluen mountains. Viewed from some little distance it looks as though a number of pigeon-holes had been irregularly hollowed out in the mountain-side. Of these excavations, Stoliczka found as many as 120. At the entrance to each working is a heap of fragments of jade and the minerals which occur in association with it—the refuse of former activity, for the quarries have been deserted for some years. The jade occurs in nests and veins, in gneissose and schistose rocks. Most of it is of pale colour, some nearly white; bright green jade being comparatively rare. It is interesting to learn from Schlagintweit that when the mineral is freshly broken from the rock, and while yet holding the "quarry water," it is so soft as to be readily scratched with a good knife, but that it gradually hardens on exposure to the atmosphere. The hardness of Oriental jade is about equal to that of felspar, and the hardness of jadeite, though slightly higher, never exceeds that of quartz.

After the expulsion of the Chinese from Yarkand, fifteen years ago, the quarries in the Karakash valley were deserted, and are now the retreat of the wolf and fox. Stoliczka remarks that if the quarries still remain unworked, if the people of Turkestan are too apathetic to quarry the stone and export it to China. the supply to the celestial carvers will probably become scant, and Oriental objects in jade will consequently become rare and valuable.

Pebbles of jade may be found in many of the streams which come down from the Kuenluen range, and it may therefore be concluded that the mineral is pretty widely distributed throughout this district. According to Schlagintweit it is not found in the Himalayas or in any part of India proper. Nevertheless jade, both in a raw state and carved into ornamental objects, is well known in India. Some remarkable specimens of jade from India, enriched with settings of brilliantly-coloured stones, were in the collection of the late Colonel Guthrie, and are now exhibited in the India Museum. It is difficult to find the precise source of the Indian-worked jade, the natives having merely a vague idea that it comes from a great distance. It appears certain, however, that jade or jadeite occurs in Burmah. None of the jade from Turkestan, it may be observed, can be referred to the species jadeite.

While referring to the occurrence of jade in Asia, mention should be made of the Siberian nephrite, which was first introduced to the western world at the International Exhibition of 1862. M. Alibert, who brought from Irkutsk such wonderful examples of graphite for the use of our lead-pencil makers, also brought some beautiful specimens of dark green jade. The mineral occurs in the form of boulders, embedded in a sandy soil, but is by no means common. The specimens brought by

Alibert were found in the Toonka range of the Sayan chain, in the Government of Irkutsk. There seems no reason why this beautiful mineral should not find its way from Eastern Siberia to the jade-loving Chinese.

While America has given to us, through its Spanish invaders, the word "jade," and Asia has furnished us with the finest examples of the stone worked into ornamental forms, we must turn to the islands of the Pacific Ocean for some of the most interesting applications of this material. When New Zealand was discovered, the natives were in the habit of using implements beautifully worked in a dark green stone, which they called in the Maori language, *punamu*, signifying "green-stone." So characteristic is the occurrence of this valuable material along the western coast of the South Island that the natives have given to this district the name of *Te Wahi Punamu*, or "Place of the Green-stone"—an expression which has been corrupted by some writers on mineralogy until it appears in one treatise under the curious guise of "Tawai Panama!" No doubt the name "punamu" is not used by the Maories with mineralogical precision, but includes a number of different minerals, and perhaps even rocks, all characterized by a more or less decided green colour, of which the most highly-prized is the true jade. This mineral occurs as pebbles, partly in the beds of rivers and partly along the sea-shore, and is also found *in situ*. By expenditure of prodigious labour, the natives work the intractable stone into axes and adzes, and especially into that peculiar weapon known as the *mere* or *pattoo-pattoo* (Pl. VIII. fig. 3). This is a short, flat, leaf-shaped hand-club, which is held by a thong passing through a hole in the handle, and securely bound round the wrist. It is only the great Maori chieftains who possess jade meres, the commoner forms of this weapon being made of less valued stones, and even of wood and bone. The jade meres are handed down from generation to generation as precious heirlooms, and are prized with superstitious veneration. Some excellent specimens of the mere may be seen in the Ethnographical Gallery in the British Museum, where some of the jade weapons show the effect of the intense heat to which they were exposed during the fire at the Government House in Auckland. Fig. 4, Pl. VIII., represents a singularly fine mere of jade seen by Hochstetter, the geologist on the exploring ship "Novara," in the possession of the mighty Maori chief, Te Heuheu.* General Lane Fox has called attention to the fact that the mere is used for prodding the enemy with its sharp end, and not for striking a blow, as with an ordinary club, since the latter act would endanger the weapon. Jade, it is true, is an uncommonly tough material; but it is

* "New Zealand," By Dr. F. von Hochstetter. Stuttgart, 1867, p. 362.

not every pattoo-pattoo which is made of so resistant a material, and those of more fragile stone might easily get shivered in a fray.*

Another favourite mode of applying jade in New Zealand is to carve it into the curious ornament or amulet, known as *Hei Tiki.* This ornament, which is worn upon the breasts by Maori chieftains, presents the form of a grotesque human figure, generally having its huge eyes inlaid with the iridescent shell of *Haliotis*, and sometimes of late years with sealing-wax, the red wax contrasting strongly with the green-stone. Fig. 5, Pl. VIII. represents one of these figures. From the fact that the lower edge of the tiki is always sharp, General Lane Fox infers that it may have been derived from the type of the celt.

Jade is likewise a favourite material with the natives of New Caledonia, who find it in their island, and fashion it into various kinds of axe-heads. It also occurs in some of the other islands of the Pacific Ocean.

No jade has ever been recorded from Africa, and it is extremely doubtful whether it occurs in Europe. It is said to have been found in the form of boulders at Potsdam near Berlin, and at Schwemsal near Leipzig. It remains, however, uncertain whence the mineral was originally derived, and whether it had been transported by natural or by human agency. In the Great Exhibition of 1851 there was a large mass of pale green jade, reputed to have come from Turkey; but nothing more was known of its origin, and its existence probably does not vitiate the general statement that no true jade or jadeite has yet been found *in situ* in Europe.

But although jade is not now known to occur in this quarter of the world, it was used by some of the early inhabitants of Europe in prehistoric times. Small celts of jade are occasionally found in the tumuli of Brittany, and in some other parts of France; while they are familiar enough to the explorers of the pile dwellings in the lakes of Switzerland.† It seems, however, that the material was regarded as of great value, even in early times, for these implements are comparatively rare. Thus among the hundreds of stone celts found in the settlement of Lüscherz, on the Lake of Bienne, only about thirty are of jade and jadeite. Still, the presence of this material, even in a solitary example, is sufficient to raise the perplexing question, How did the men who reared such curious structures in the Swiss lakes manage to secure a material for which they might

* "Note on the Use of the New Zealand Mere." "Journ. Ethnolog. Soc." New Series, vol. ii., 1870, p. 106.

† See Dr. J. E. Lee's translation of Keller's "Lake Dwellings," 2 vols. Second Edition, 1878.

seek in vain throughout the length and breadth of Europe? Did they obtain it by barter with people from the East—by early intercourse with China, or Turkestan, or Siberia—or did the old lake-dwellers, when driven westwards from their Asiatic homes, bring with them their much-valued implements of jade?

As a remarkable example of an archaic implement in jade, attention may be called to an unique celt which was brought from Egypt many years ago by Captain Milner, and is now in the Christy Collection. The peculiarity of this implement lies in the fact that it bears upon its two faces Gnostic inscriptions neatly engraved in Greek characters. The general appearance of the celt, and the mode in which the inscription is incised—on one side in eight lines, on the other side in eighteen leaves upon a spiral axis—are sufficiently shown in figs. 6 and 7, Pl. VIII. It is believed that the engraving was executed at Alexandria during the third or fourth century of our era; but the celt itself is no doubt of much older date. Supposing it to have been picked up, the fortunate finder would regard it, in accordance with early opinion on such objects, as a ceraunia, or thunderbolt—a holy thing fallen from Jupiter—on which a mystic formula might appropriately be engraved, with the advantage of making the spell doubly potent.*

Although this remarkable specimen was found in Egypt, we are not aware that the ancient Egyptians ever employed jade as the material on which to exercise their glyptic art. It is true that some authorities have referred to jade as *pietra d'Egitto*,† but there is here probably some mistake in the identification of the stone. Egyptian amulets and sepulchral ornaments are not unfrequently wrought in green stones, but these are mostly either jasper or felspar. The latter is the material now called *Amazon stone*; but it should be noted that many of the older writers refer to jade under this name, whence it has been inferred that jade occurs in South America.

All modern mineralogists, however, restrict the term Amazonite to an apple-green felspar, which until lately was referred to the species *Orthoclase*, but which has recently been shown by Des Cloizeaux to be a variety of *Microcline*. At the present time the finest Amazon stone comes, not from the Amazons, but from Siberia, Labrador, and Colorado. It is uncertain, however, whence the Egyptians derived the green felspar which they employed. This felspar was used also by the Assyrians, who occasionally worked it into the well-known

* "On a Ceraunia of Jade converted into a Gnostic Talisman," by C. W. King, M.A. "Archæolog. Journ.," vol. xxv. 1868, p. 103.

† Blumenbach, e.g. in his "Handbuch d. Naturgeschichte," 1797.

cylindrical seals which are so exquisitely engraved with figures and arrow-headed inscriptions. It appears, however, that jade was likewise used by the Assyrian engravers, for there is at least one cylinder in the British Museum which is described as being of this material.

On the whole, then, it appears that jade, though unquestionably employed by prehistoric man in Western Europe, was but little known in the great centres of early civilization in the East. By Greek and Roman artists the material was rarely, if ever, used; the engraved celt, already referred to, being a solitary example of Greek engraving, and only upon a stone which had been worked into shape by an earlier and a foreign hand. Nor was the material used, so far as we know, by mediæval artists. Indeed, Mr. King, the great authority on antique gems, after referring to the introduction of jade on the Spanish conquest of America, says: "Even had the jade been known at an earlier period, the ancient love of the beautiful and their correct taste would have prevented their throwing away their labour and time upon so ugly and refractory a material." *

If so unfavourable an opinion is shared by other connoisseurs, though assuredly no lover of Oriental art will join in the condemnation, it is no wonder that jade has not been used in modern times by European artists. Of late, however, a small quantity of a beautiful green variety of jade has been imported in the rough from New Zealand, and has been cut and polished both in this country and in Germany into the form of ear-drops and other trivial objects of personal ornament.

It will have been gathered from the foregoing part of this article that the term jade has been vaguely applied to a number of different mineral-substances more or less akin in their physical properties, and all capable of being used for ornamental purposes. Even the most experienced mineralogists have, until within the last few years, included under this term two or three substances which agree in possessing various shades of green colour, and in having an extreme toughness, but which differ widely in chemical composition. It is desirable, before closing this article, to clearly differentiate these several minerals.

In 1846 M. Damour published an analysis of a piece of the well-known whitish Oriental jade, which had been carved in India.† From his analysis he concluded that this kind of jade was essentially a silicate of magnesium and calcium, and might be regarded as a form of hornblende, comparable with the

* "Antique Gems," by the Rev. C. W. King, M.A., 1860, p. 98.

† "Analyse du Jade Oriental; réunion de cette substance à la Trémolite." "Annales de Chimie et Physique," sér. iii. t. 16, 1846, p. 469.

variety called, from the Swiss valley of Tremola, *Tremolite.* Subsequent analyses of some of the dark green jade of New Zealand have shown that this also may have a similar composition, and may be referred to the green variety of hornblende called, from the radiated structure which it characteristically presents, *Actinolite.* Both these kinds of jade are therefore hornblendic or amphibolic minerals, similar in chemical composition to well-known minerals occurring abundantly in Europe and elsewhere, but differing from them in certain physical characteristics. No forms of tremolite or of actinolite are known in Europe to which the designation of jade can fairly be applied.

The specific gravity of this hornblendic jade, distinguished by Damour as *Oriental Jade,* is about 3. Mr. T. Davies, of the British Museum, who has determined the density of upwards of a hundred specimens from New Zealand, gives the limits between 3·00 and 3·02.* It may seem trivial to dwell upon this point, but it will be presently seen that specific gravity offers a valuable means of diagnosing the jades.

Some other examples of New Zealand jade examined by Damour yielded very different proportions of lime and magnesia, and the analyses lead to a formula more like that of augite or pyroxene than of hornblende. In physical properties it closely resembles the Oriental variety, but differs in having a specific gravity of about 3·18. It appears to be a rare mineral, and as it is known only from New Zealand and the Marquesas Islands, it has been distinguished as *Oceanic Jade.*† It must not be forgotten, however, that most of the jade of the Pacific Islands belongs to the hornblendic and not to the augitic form.

On examining a sample of green jade, about sixteen years ago, M. Damour found so great a difference in its composition from that of either the Oriental or the Oceanic nephrite, that he proposed to regard it as a distinct mineral under the name of *Jadeite.*‡ It is a silicate of aluminium, sodium, calcium, magnesium, &c. Its specific gravity varies between 3·28 and 3·35, and is therefore higher than that of jade: it is also harder, and hence jadeite will scratch a piece of ordinary jade. Damour placed this mineral near to Wernerite. It is this substance which, as mentioned above, occurs in Yunnan, and is known as *feit-sue.* Many of the celts found in Brittany and in

* "Notes on Jadeite and Jade." By Thomas Davies, Esq., F.G.S. Appendix to Lee's translation of Keller's "Lake Dwellings," 2nd ed. vol. i. p. 683.

† "Sur la composition des haches en pierre trouvées dans les monuments celtiques et chez les tribus sauvages." Par M. Damour. Part II. "Comptes Rendus," t. lxi. 1865, p. 357.

‡ "Notice et analyse sur le Jade vert: réunion de cette matière minérale à la famille des Wernerites." "Comptes Rendus," t. lvi. 1863, p. 861.

the Swiss lake-dwellings are composed of this substance. No jadeite, however, has been found *in situ* in Europe. For numerous analyses of jade and jadeite we are indebted to Herr L. R. Von Fellenberg, whose work has been of especial interest in connection with the materials used by the lake-dwellers of Switzerland.*

Under the name of *Jade tenace* the French mineralogist Häuy described a mineral which was considered by the elder De Saussure to be a variety of jade. It was afterwards regarded by mineralogists as a distinct mineral, and was termed by the younger De Saussure (in honour of his father) *Saussurite*, a name which still holds its place in scientific nomenclature. This mineral is in many ways curiously like jadeite: its specific gravity, for example, is between 3·2 and 3·42, its hardness is about equal to that of quartz, and it is equally rich in alumina. Its chemical composition, however, brings it close to *zoosite* or *lime-epidote*. Some of the so-called jade of Turkestan is found to be Saussurite, and this mineral is also the substance in which many of the Swiss celts are wrought. In the form of boulders brought down by glacial action from the Swiss Alps, it is scattered widely through some of the Alpine valleys, and is abundant in the country around the Lake of Geneva. Pebbles of this tough material, picked up by the pile-builders on the marge of the lakes in which they dwelt, would naturally attract attention, and be utilized as a valuable material for implements and weapons. No wonder then that celts of Saussurite are found in the relics of these primitive habitations. If this mineral be admitted to rank with the jades, it will, of course, contradict the assertion that no jade occurs in Europe; and it is for this reason that the expression "true jade" has often been used in this article.

Before leaving the subject, it may be useful to cite a few analyses of jade, and of kindred minerals commonly called [illegible]le:—

	I.	II.	III.	IV.	V.	VI.
Silica . .	57·60	51·70	52·25	59·17	58·62	43·59
Magnesia .	25·61	23·50	18·07	1·15	2·23	2·98
Ferrous oxide	·66	7·62	6·80	1·56	1·86	—
Ferric oxide.	—	—	—	—	—	2·61
Lime . .	12·68	13·09	19·27	2·68	3·85	19·71
Soda . .	—	—	·68	12·93	11·64	3·08
Alumina .	·25	·65	·58	22·58	21·77	27·72
Water, etc. .	2·74	2·42	1·50	—	—	·35
	99·54	98·98	99·15	100·07	99·97	100·04

* See, for example, the "Neues Jahrbuch für Mineralogie," 1865, p. 619.

I.	White Oriental Jade from China . .	sp. gr.	2·97
II.	Green Oriental Jade from New Zealand . . .		3·015
III.	Oceanic Jade from New Zealand		3·18
IV.	Jadeite from China		3·34
V.	Jadeite from a celt found at Morbihan, France . .		3·344
VI.	Saussurite from L. Geneva		3·4

In addition to the minerals enumerated in this table, there are a few other substances which have occasionally been classed as jade. Thus, a mineral found at Rhode Island was formerly described as an American nephrite, but has been found on analysis to be only a very hard variety of serpentine, and is now distinguished as *Bowenite*. Many of the celts from Brittany are wrought in a material known as *Fibrolite*, which is a simple silicate of aluminium, but has been mistaken for jade. Again, a dark-coloured jade-like mineral, occasionally used for implements, is distinguis[illegible] [illegible]amour as *Chloromelanite*; this is a ferric-aluminic[illegible] notable for high specific gravity, which ranges from [illegible]·6. *Jasper*, when of dark green colour, has not unfreq[illegible]en taken for jade; but it need hardly be said that, tho[illegible] two substances do not differ widely in their degrees [illegible]ness, they are extremely different in density. As th[illegible]ic gravity of jasper is only about 2·6, we have an unfai[illegible] by which it may be distinguished from every kind of ja[illegible]

Excluding, however, such substan[illegible]per, which obviously have no right to claim a place in [illegible]e family, there yet remains a number of ornamental s[illegible]hich have been, and are still, popularly grouped together under the inclusive name of jade. Much as the mineralogist may desire to see these substances rigidly designated by their proper names, it must be borne in mind that their discrimination is by no means an easy task, especially to unscientific collectors of works of art, into whose hands the finest specimens usually fall. Specific gravity offers, perhaps, the easiest and surest means of diagnosis; but to determine specific gravity is not always convenient, and may be impossible, as in the case of jade objects mounted in metal. Chemical examination is, of course, out of the question in ninety-nine cases out of a hundred. Hence it sometimes becomes difficult even for a mineralogist to determine with precision the real mineralogical nature of a given specimen. It is then that a vague name like jade may still be retained with advantage, its value depending, in fact, upon its very vagueness. Even the greatest stickler for scientific precision must admit that there are occasions when he is compelled to lay aside his scruples, and to make a ruthless sacrifice of Accuracy on the altar of Convenience.

EXPLANATION OF PLATE VIII.

FIG. 1. Ancient Mexican Mask in Jadeite, probably an example of the Chalchihuitl, now in the Museum of Practical Geology. Natural size.

„ 2. A Joo-ee, or Chinese wand of authority, carved in Oriental jade.

„ 3. Mere, or patoo-patoo, carved by the Maories of New Zealand in jade, known as punamu.

„ 4. Mere in punamu, curiously ornamented, belonging to a Maori chieftain, Te Heuheu.

„ 5. Hei-tiki, or Maori amulet, worn upon the breast; carved in jade or punamu. Half size, linear.

„ 6 & 7. A jade celt, or ceraunia, with Gnostic inscription in Greek characters upon the two faces; found in Egypt, and now in the Christy Collection of the British Museum.

REPORT ON AMERICAN DREDGINGS IN THE CARIBBEAN SEA.

By ALEXANDER AGASSIZ.*

I JOINED the *Blake* at Washington, on November 27, 1878, for a second dredging cruise. According to your instructions, we intended to proceed to Nassau, and there devote a few days to dredging and sounding, in order to trace the connection between the fauna of the northern extremity of the Bahama Banks and that of the Straits of Florida. Owing to rough weather this was not deemed prudent, and we were compelled to put into St. Helena Sound, and, for the same reason, when off Jupiter Inlet, instead of crossing the Gulf Stream to make Nassau, it was thought best to put into Key West. From there, when the weather moderated, we started from Kingston, Jamaica, calling at Havana for the purpose of making a couple of hauls on the Pentacrinus ground discovered by Captain Sigsbee off Morro Light. We made two casts of the dredge in 175 to 400 fathoms, and obtained a few specimens of Pentacrinus. We kept on along the northern shore of Cuba, through the Old Bahama Channel, without stopping to sound or dredge, Mr. Pourtalès having in former years dredged and sounded, in the *Bibb*, Acting Master Platt, U.S.N., over the greater part of this line.

At the eastern end of the Old Bahama Channel we ran a line of dredgings and soundings across from Caya Crux to Lobos Light. In the deepest part of the channel we found only 500 fathoms, although the hydrographic maps indicated 900 fathoms; no bottom. This is an excellent example of the uncertainty of the old method of sounding with hemp rope, even in moderately deep water, when there is a strong current, such as we found here.

* The following report of the dredging operations of the U. S. Survey steamer *Blake*, during the winter of 1878–79, contains so great an amount of interesting information that we have thought it well worth reprinting for the benefit of the readers of the "POPULAR SCIENCE REVIEW."

Nothing of special interest came up in any of the casts made either with the trawl or dredge. Wound around the steel-wire rope on this line, however, we found a few pieces of the deep-sea Siphonophores (Rhizophysa), described lately by Studer in the "Zeitschrift für wissensch. Zoologie." Subsequently we frequently found more or less complete specimens of these Siphonophores, generally entangled on the wire rope or attached to the trap of the trawl. Studer gives a long list of the depths from which they came up attached to the sounding line, but it is by no means certain that these Siphonophores belonged to the depths indicated by the wire. They may have become caught on the wire while it was reeling in at only a short distance from the surface.* The fact that Studer never succeeded in bringing up any of these species in the tow-net, even when lowered to a considerable depth, is as little conclusive, since, at any rate in the Caribbean Sea, their isolated parts and fragments are not uncommon floating on the surface. It is probable that they usually live at a certain depth below the surface, and some of them may, like Cassiopea, prefer to dwell near the bottom; but until we possess a net so constructed as to give some sure indication of the intermediate depths at which the animals living at various distances between the surface and bottom have been gathered in, it seems hazardous to define the bathymetrical range of a large number of pelagic animals, such as the Acalephs, Siphonopores, Heteropods, Pteropods, numerous Foraminifera, Radiolaria, and the like, the habits of which are scarcely known.

In the case of fishes, when dredging in deep water at a moderate distance from the land, we ought not to take it for granted that they invariably live at the depth to which the trawl may have been lowered. The young of many of the deep-water fishes are undoubtedly pelagic, often till a late period of growth; and thus many of the deep-water fishes have probably come to light, especially in the proximity of oceanic islands, or along coasts situated near deep water. We made three casts off the coast of Cuba between Nuevitas and Cape Maysi. In lat. 21° 2′ N., long. 74° 44′ W., off Cay de Moa, in 1,554 fathoms, we found a patch of green sand, made up of large Globigerinæ, similar to that mentioned by Mr. Pourtalès in his "Deep-Sea Corals."

We also obtained, in 994 fathoms, off Nuevitas, large blocks of genuine white chalk, composed mainly of Globigerinæ and

* In one case, dredging in 1,000 fathoms, numerous fragments of a Rhizophysa came up after drawing in 100 fathoms of wire! On another occasion, the same species came up after drawing in 300 fathoms, while dredging in 500 fathoms.

Rotalinæ. Large quantities of ooze and white clay, which proved to be only the white chalk in different stages of compression, also came up in the trawl. If the conditions now existing at that depth at all resemble those of the time of the white chalk, I could readily understand how perfectly sea-urchins or molluscs would be preserved if once enclosed in this homogeneous substance, to be gradually compressed into solid white chalk.

In one of the hauls taken between Cape Maysi and Jamaica (1,200 fathoms), we obtained the first specimens of Phormosoma I had seen alive. I was much astonished to find them, fully blown up, hemispherical or globular in shape. This was the shape they always took in subsequent hauls, and on several occasions, when they were obtained from comparatively shallow water, near the 100 fathom line, they came up fully alive and retained their globular outline. The alcoholic specimens I had seen in the *Challenger* collections came up as flat as pocket-handkerchiefs, from great depths, and were naturally regarded as flat sea-urchins, although of course endowed with great mobility of test. These Echini, with their globular flexible tests, recall vividly the Perischoechinidæ, with which they have also points of resemblance of great interest in the structure of their ambulacral and interambulacral plates.

In the dredgings taken off the south-eastern end of Jamaica, we did not bring up anything of great importance. From Jamaica we were obliged, owing to the strong trades, to keep on towards St. Thomas, without either sounding or trawling, till off Porto Rico. During the winter months the trades blow sufficiently hard to make dredging and sounding quite uncomfortable on a vessel of the size of the *Blake*. We had, therefore, no opportunity of adding anything to the hydrography of that part of the Caribbean Sea.

On arriving at St. Thomas's we made a programme for our season's work. This we were fortunate enough to carry out to the letter, as far as the dredging and sounding were concerned. With the exception of the time required for coaling and overhauling the engine at Martinique and St. Lucia, not a single day was lost. Although Lieutenant-Commander Sigsbee, U.S.N., did not command the *Blake*, yet the improvements which were made this year in the dredging and sounding apparatus were all carried out under his supervision, the vessel having been fitted out for sea before he was relieved by Commander J. R. Bartlett, U.S.N., who commanded the *Blake* during this winter. It was also my good fortune to find on board the majority of the officers with whom I sailed in the winter of 1877–78. We thus started under the very best auspices. In the use of the improved machinery, suggested by our former cruise, the ex-

perience of the old officers saved us from the annoyances which always accompany the introduction of new methods. The *Blake* was this year provided with a new double-cylinder reeling-engine, built by Copeland and Bacon, placed at right angles to the reel, on which our steel rope was wound. A small double engine revolved the reel, so that the wire rope was wound independently of the main reeling-engine. The wire rope was led to the port side directly from the main reeling-engine, then by a large wrought-iron sheave along the deck to the mainmast, thence across to the starboard side, and then along the deck to the reel, upon which it was wound. This worked admirably, relieving the reel, which thus became a mere spool, from all strain either in winding up or in dredging, the whole strain being taken up by the ten turns of the wire rope on the surging drum of the main reeling-engine. The arrangements for leading off the wire from the bow of the ship, through a large sheave at the end of the dredging-boom, were practically the same as last year. The steel spring accumulator was, however, replaced this year by one of car-rubber springs, suspended along the foremast, and to this accumulator was attached the pendant, running along the dredging-boom which carried the dredging-pulley. As Lieutenant-Commander Sigsbee is soon to publish, in one of the Coast Survey Reports, a full account of the dredging and sounding apparatus used on board the *Blake*, I will not speak in greater detail of our apparatus.

No change was made in our dredges. In the trawls several new forms were tried, but we found that the most satisfactory trawl was of the shape adopted last year, the only important change being the greater height of the runners—30 inches. The bar connecting the runners was used as a frame to stretch a sheet of netting across the whole beam, so as to divide the trawl opening into two halves, each opening into the trap. This enabled us to give a longer lead line to the mouth of the double trawl, without the danger of fouling from the lead line of the other side. The only change I could still suggest would be that this lead line should run through rings at the corners of the runners; the strain on the side which fell on the ground would take up the slack of the upper side, and thus increase still further the sweep of the trawl. Our trawl-nets were made much shorter than last year, and for deep work, when so much ooze is always likely to choke the trawl, it would be advisable for a ten-foot beam to have a net of not more than twelve to fifteen feet in length.

We also tried dragging a heavy tow-net rapidly over the ground at great depths, in hopes of catching the more active crustacea and fishes; but we found that, after all, no deep-sea machine worked better than a trawl, which, when moved rapidly

over the ground, at the rate sometimes of two to two and a-half miles an hour, invariably brought up a fine harvest of fishes and crustacea, in addition to the usual contents of the sedentary and more sluggish forms. Although the deep-sea tow-net was used several times, we never brought up any of the so-called deep-sea Siphonophora of Studer, even in localities where they came up on the wire rope.

Captain Sigsbee's new sounding machine worked admirably, and he has every reason to be entirely satisfied with the improvements he has made upon his former machine.

We carried 6,000 fathoms of new galvanized steel-wire rope $1\frac{1}{16}$ inch in circumference made by the Roebling Sons' Company, which, owing to its greater pliability, proved even more satisfactory than the wire rope used on the last cruise. The steel-wire rope continued during our whole cruise to give complete satisfaction, and enabled us, as in the previous year, to work with the greatest possible rapidity consistent with safety and with the proper handling of the trawls and dredges.

We usually lowered in deep water at the rate of four to four and a-half or five minutes per 100 fathoms, and reeled in at the same rate. In the many places where we found rough or rocky bottom we used a flat bar of six-foot beam, to which rings were attached for fastening tangles and a shot. This bar, with from a dozen to fifteen bundles of tangles, proved perhaps our most effective machine in rough bottoms. It rarely fouled, as the dredges or trawls are so apt to do, when working over unfavourable ground. The region over which we chiefly worked this year extended from St. Thomas to Trinidad. Over a limited area like this it was possible to cover the ground very satisfactorily. The work done off the principal islands began usually at the 100-fathom line, and extended into the deepest water off the lee side of the Caribbean Islands. But little could be done in the way of dredging in the passages between the islands or to the windward of them, owing to the strong trades. While working off Barbadoes we undoubtedly obtained a fair representation of the fauna to the windward of the Caribbean Islands, which does not seem to differ from that of the lee side.

During this season we occupied no less than 200 stations, and made over 230 hauls from the 100-fathom line to the depth of 2,412 fathoms. A few hauls were occasionally made in shallow water, but they formed no part of our regular scheme. Although we have obtained from the West India Islands some of the most interesting invertebrates, yet we did not find the fauna of the eastern extremity of the Caribbean Sea materially different from that of the Gulf of Mexico and the Straits of Florida. It certainly is by no means as rich in animal life at

great depths. We rarely got from deep water, say between 1,500 and 2,400 fathoms, the rich hauls so invariably made in the Gulf from depths of between 1,200 and 2,000 fathoms. But we found, what was much more important for our success, that the range of the greater number of deep-sea species extended within very easy dredging limits, and we soon discovered that by dredging mainly between 300 and 1,000 fathoms we not only obtained nearly all the species extending to the 2,000-fathom line, but obtained them in considerable numbers. This enabled us, of course, to collect a large amount of material, and the collections of this year's cruise, combined with those of the previous year, added to the older collections made by Count Pourtalès on the *Bibb* and to those of the *Hassler*, make our deep-sea collections but little inferior to those of the *Challenger*.

I was greatly struck with the large number of our species, which, if not identical, are at least closely allied to those brought home by the *Challenger*; and I was specially disappointed at the absence of types not already collected by the great English expedition. I think it can be fairly stated that the great outlines of the deep-sea fauna are now known, and that, although many interesting forms will undoubtedly be dredged in the shallower waters, between 100 and 300 fathoms, we can hardly expect to add materially to the types discovered by the dredging expeditions of the last ten years. As has been well said by Mr. Moseley, of the *Challenger*, it becomes somewhat monotonous to find constantly the same associations of invertebrates in the deeper hauls, and it is only in shallower waters that it is possible to keep up one's enthusiasm after a few months' work. I should be inclined, from the experience of the past two years, to carry the range of the deep-sea fauna as high as 300 or 350 fathoms, and to call the littoral fauna the species extending mainly to the 100 or 150-fathom line; from the 100 to the 300 or 400-fathom line extend the species which are neither littoral nor yet have the wide geographical range belonging to species found beyond that depth. But this upper limit of the deep-sea fauna must, of course, depend upon the temperature, and undoubtedly varies greatly from local or partly local causes.

While dredging to the leeward of the Caribbean Islands we could not fail to notice the large accumulations of vegetable matter and of land *débris* brought up from deep water many miles from the shore. It was not an uncommon thing to find at a depth of over 1,000 fathoms, ten or fifteen miles from land, masses of leaves, pieces of bamboo, of sugarcane, dead land shells, and other land *débris*, which are undoubtedly all blown out to sea by the prevailing trade-winds. We frequently found floating on the surface masses of vegetation, more or less water-

logged and ready to sink. The contents of some of our trawls would certainly have puzzled a palæontologist; between the deep-water forms of crustacea, annelids, fishes, echinoderms, sponges, etc., and the mango and orange leaves mingled with branches of bamboo, nutmegs, land shells, both animal and vegetable forms being in such profusion, he would have found it difficult to decide whether he had to deal with a marine or a land fauna. Such a haul from some fossil deposit would naturally be explained as representing a shallow estuary surrounded by forests, and yet the depth might have been 1,500 fathoms. This large amount of vegetable matter, thus carried out to sea, seems to have a material effect in increasing, in certain localities, the number of marine forms.

The collections made have all arrived in Cambridge, and will be sent for determination, as fast as practicable, to the naturalists who have undertaken the reports on the different groups of last year's collections. As their preliminary reports are well under way, I need only allude here in general to some of the most interesting types. Among the Foraminifera are a number of the arenaceous types noticed by Mr. Brady, in the collections of the *Challenger* and *Porcupine*; among the Sponges, a species allied to Phoronema, a small Hyalonema, tufts of large, siliceous spicules (Hyalonema proper), covered at one end with Zoanthus, very similar to the common Japanese type; fine series of Dactylocalyx, showing the mode of growth from a simple globular form; and a gigantic Euplectella. The collection of Starfishes was quite small, and contained nothing worthy of special notice. The collection of Holothurians contained, in addition to the deep-sea forms mentioned in my former letters, a larger number of species than last year, genera allied to Molpadia, Caudina, Echinocucumis, and the like.

Among the Echini, with the exception of the Pourtalesia group, all the types collected by the *Challenger* are well represented, with a few Spatangoids hitherto unknown. The number of Echinothuriæ was quite large. Of the Pourtalesia group but few specimens in good condition were obtained, though the trawl brought up numerous fragments of several of the genera (if I am not mistaken) collected by the *Challenger* in deep waters in the Southern Ocean. The small number of Clypeastroids collected, even when approaching the South American shore, at the 100-fathom line, near Trinidad, where they are so common, shows pretty conclusively that the group, with the exception of Echinocyamus, is an eminently littoral one. A large collection of Comatulæ was made, and a number of specimens of Rhizocrinus were obtained, but only a few were in perfect condition. Of Holopus only a part of a specimen was found. It was collected off Montserrat, and escaped my atten-

tion; although, of course, on the look-out for black Holopus, I did not notice this imperfect whitish specimen, which must have been alive, among the numerous Pentacrini with which it came up. Our collection of Pentacrini is quite extensive; we found them at Montserrat, St. Vincent, Grenada, Guadeloupe, and Barbadoes, in several places, in such numbers that on one occasion we brought up no less than 124 at a single haul of the bar and tangles. We must, of course, have swept over actual forests of Pentacrini crowded together much as we find the fossil Pentacrini on slabs. Our series is now sufficiently extensive to settle satisfactorily the number of species of the genus found in the West Indies. There are undoubtedly the two species which have thus far been recognized. It is evident that they vary greatly in appearance, *P. Mülleri* being the most variable. I have nothing to add to the general description of their movements given by Captain Sigsbee in my second letter, with the exception of their use of the cirri placed along the stem. These they move more rapidly than the arms, and use them as hooks to catch hold of neighbouring objects, and, on account of their sharp extremities, they are well adapted to retain their hold. The stem itself passes slowly from a rigid vertical attitude to a curved or even drooping position. We did not bring up a single specimen showing the mode of attachment of the stem. Several naturalists, on the evidence of large slabs containing fossil Pentacrini, where no basal attachment could be seen, have come to the conclusion that Pentacrini might be free, attaching themselves temporarily by the cirri of the stem, much as Comatulæ do. I am informed, however, by Captain E. Cole, of the telegraph steamer *Investigator*, that he has frequently brought up the West India telegraph cable on which Pentacrini were attached, and that they are fixed, the basal extremity of the stem spreading slightly, somewhat after the manner of Holopus, so that it requires considerable strength to detach them.

The collection of Ophiurans is perhaps the largest ever made. They seem to play a very important part in determining the facies of a fauna. They occur everywhere, at all depths, and often in countless numbers. I hardly think we made a single haul which did not contain an Ophiuran. They often came up when the trawl brought nothing else. In some places the bottom must have been paved with them, just as the shallows are sometimes paved with Starfishes and Echini, and many species hitherto considered as extremely rare are found to be really abundant. Most, or perhaps all, the deep sea Atlantic species obtained by the *Challenger* have been re-discovered in large numbers. Such rare species as *Sigsbeia murrhina*, *Ophiozona nivea*, *Hemieuryale pustulata*, and *Ophiocanax hystrix*, were found in plenty. Among the representatives of northern seas

may be cited *Astronyx Loveni* (?) while a single specimen of Ophiophyllum represents the great rarities. Of *Astrocnida isidis*, of which only three specimens were known, we have half a dozen. A large Pectinura recalls the shallow fauna of the East Indies; while a new Ophiernus brings to mind the Antarctic deep-sea forms. Finally, the supposed abundance of simple-armed Astrophytons is fully confirmed by the various species of Astrochema, and by a new species of Ophiocreas.

The diligent search of Count Pourtalès in the Straits of Florida, the *Hassler* expedition, the *Challenger* explorations, and the two expeditions of the *Blake*, have evidently brought up the majority of the species of Ophiurans; for among the enormous mass of specimens this time obtained, the number of new species is not very great.

The Hydroids and Bryozoa were mainly represented by the same forms as those collected last year, or in former coast survey expeditions in the Florida Straits.

The corals, although abundant in specimens and species, probably contain but few undescribed ones. Very fine specimens of the larger, simple corals obtained by the *Challenger* expedition, which were never found in our earlier dredgings in the Gulf of Mexico, or the Straits of Florida, were dredged here, such as Flabellum, Trochocyathus, Ceratotrochus, etc. Several of the deep-sea Actiniæ, described by Moseley, were obtained, generally attached to sponge spicules, Gorgoniæ, or stems of Umbellariæ.

The Alcyonarians were also very abundant, and among them we expect to find many novelties. Little can be said of them at first view, as the deep-water forms have thus far received but little attention. One form, growing in a regular spiral, with equidistant branchlets on the outer side of the spire, seems, by this mode of growth, to differ from anything previously known in that order. Several fine specimens of Umbellaria were obtained.

Among the Annelids, the tubicolous Annelids are by far the most striking, from the exquisite beauty of their tubes, composed of siliceous spicules, and dead Pteropod shells, and from their strange associations with Corals, Gorgoniæ, sponges, and even molluscs. A species of Phorus was frequently accompanied by a large Annelid, comfortably established in the axis of the shell, with the head close to the aperture.

Among the crustacea we found again the *Bathynomus giganteus*, A. M. Edw., discovered last year. We also brought up from 734 fathoms a Pycnogonum, measuring not less than two feet along the legs, when fully extended; a fine *Astacus zealacus*; and, from 416 fathoms, a magnificent species, allied to Nephrops, blind, but with rudimentary eye-stalks. An in-

teresting isopod, with gigantic lateral processes on the posterior segment, was also obtained from 300 fathoms. Many hermit-crabs occupied tubes of bamboo or cavities in dead wood and sponges, of which they completely closed the orifice, with one of the large claws flattened like the operculum of a Serpula.

Among the molluscs, the preliminary report of Mr. Dall (in Letter No. 2), mentions the most important types. We obtained, however, in addition, a good set of Pleurotomaria, one specimen measuring five inches in height, while another was so small that the slit, from which the genus takes its name, existed only as a slight indentation. I hope to supply Mr. Dall with the material necessary for an anatomy of this interesting genus. But by far the most interesting of the molluscs is a Spirula, from a depth of 950 fathoms, in excellent condition. The small number of Waldheimia collected this year is quite striking; other species of Terebratulæ were more common. We found, as was usual last year, an immense number of dead Pteropod shells at all depths, playing a most important part in determining the nature of the deep-sea bottom.

The collection of fishes is excellent; its special characteristic is the large number of Lophioid types it contains. We also obtained many of the genera collected by the *Challenger*. Some of the rarer pelagic fishes, which are occasionally caught at sea, are undoubtedly either full-grown deep-sea fishes or their young. It becomes an interesting problem to know where the young remain, before they become permanently inhabitants of deep water.

The pelagic fauna of the eastern part of the Caribbean Sea is, during the winter season, rather scanty. Owing to the constant agitation of the water, I had no opportunity, as in the Gulf, to make much use of the surface tow-net. From the number of fragments of Siphonophora constantly found they must be very numerous. In the roadstead, under the lee of the islands, there was but little pelagic life to be found. Everything either remains at a short distance below the surface, or is blown out to seaward of the islands. The phosphorescence, in consequence, is far less brilliant than in the Gulf of Mexico, although occasionally the masses of Ctenophora (a species of Mnemiopsis), swimming at different depths, produce a very striking illumination; sudden flashes of light suddenly appearing as if coming from great balls of fire floating a short distance below the surface. The most striking phosphorescent phenomena were produced by a small Annelid, allied to Syllis, which moved over the surface of the water with great rapidity, performing the most remarkable gyrations, and tracing its path, which remained phosphorescent for a short time, by a brilliant line of light. Among the deep-water forms, several of the

species of Gorgonia and Antipathes (especially Rüsea), showed a bright bluish phosphorescence when coming up in the trawl. One Ophiuran also, like one of the Mediterranean species mentioned by Panceri, was exceedingly phosphorescent, emitting along the whole length of its arms at the joints a brilliant bluish-green light.

One of the most interesting results reached by this year's cruise is the light thrown upon the former extension of the South American continent, by the soundings taken while dredging, and those subsequently made in the passages between the islands by Commander Bartlett. These, together with the soundings already known, enable us to trace the outline of the old continent with tolerable accuracy, and thus obtain some intelligible, and at the same time trustworthy, explanation of the peculiar geographical distribution of the fauna and flora of the West India Islands. As is well known, Cuba, the Bahamas, Hayti, and Porto Rico, instead of showing, as we might naturally assume from their present proximity to Florida, a decided affinity in their fauna and flora with those of the Southern United States, show, on the contrary, unmistakable association with those of Mexico, Honduras, and Central America; the Caribbean Islands show in part the same relationship, though the affinity to the Venezuelan and Brazilian fauna and flora is much more marked.

In attempting to reconstruct, from the soundings, the state of things existing in a former period, we are at once struck by the fact that the Virgin Islands are the outcropping of an extensive bank. The greatest depth between these islands is less than forty fathoms, this same depth being found on the bank to the east of Porto Rico, the 100-fathom line forming in fact the outline of a large island, which would include the whole of the Virgin Islands, the whole of Porto Rico, and extend some way into the Mona Passage. The 100-fathom line similarly forms a large plateau, uniting Anguilla, St. Martin, and St. Bartholomew. It also unites Barbuda and Antigua, forms the Saba Bank, unites St. Eustatius, St. Christopher, Nevis, and Redonda. It forms an elongated plateau, extending from Bequia to the south-west of Grenada, and runs more or less parallel to the South American coast from the Margarita Islands, leaving a comparatively narrow channel between it and the 100-fathom line south of Grenada, so as to enclose Trinidad and Tobago within its limits, and runs off to the south-east in a direction also about parallel to the shore-line. At the western end of the Caribbean Sea the 100-fathom line forms a gigantic bank off the Mosquito coast, extending over one-third the distance from the mainland to the island of Jamaica. The Rosalind and Pedro Banks, formed by the same line, and a few other smaller banks, denote

the position of more or less important islands which must have once existed between the Mosquito coast and Jamaica. On examining the 500-fathom line, we thus find that Jamaica is only the northern spit of a gigantic promontory, which once extended towards Hayti from the mainland, reaching from Costa Rica to the northern part of the Mosquito coast, and leaving but a comparatively narrow passage between it and the 500-fathom line encircling Hayti, Porto Rico, and the Virgin Islands, in one gigantic island. The passage between Cuba and Jamaica has a depth of 3,000 fathoms, and that between Hayti and Cuba is not less than 873 fathoms, the latter being probably an arm of the Atlantic. The 500-fathom line connects, as a gigantic island, the banks uniting Anguilla to St. Bartholomew, Saba Bank, the one connecting St. Eustatius to Nevis, Barbuda to Antigua, and from thence extends south so as to include Guadeloupe, Marie Galante, and Dominica. This 500-fathom line thus forms one gigantic island of the northern islands, extending from Saba Bank to Santa Cruz, and leaving but a narrow channel between it and the eastern end of the 500-fathom line running round Santa Cruz. As Santa Cruz is separated from St. Thomas by a channel of 40 miles, with a maximum depth of over 2,400 fathoms, this plainly shows its connection with the northern islands of the Caribbean group rather than with St. Thomas, as is also well shown by the geographical relations of its mollusca. The 500-fathom line again unites, in one gigantic spit, extending northerly from the mouth of the Orinoco, all the islands to the south of Martinique, leaving Barbadoes to the east, and a narrow passage between Martinique and the islands of Dominica and St. Lucia. At the time of this connection, therefore, the Caribbean Sea was connected with the Atlantic only by a narrow passage of a few miles in width between St. Lucia and Martinique, and one somewhat wider and slightly deeper between Martinique and Dominica, another between Sombrero and the Virgin Islands, and a comparatively narrow passage between Jamaica and Hayti. The Caribbean Sea, therefore, must have been a gulf of the Pacific, or have been connected with it through wide passages, of which we find the traces in the Tertiary and Cretaceous deposits of the Isthmus of Darien, of Panama, and of Nicaragua. Central America and northern South America at that time must have been a series of large islands with passages between them from the Pacific into the Caribbean. It is further interesting to speculate what must have become of the great equatorial current produced by the north-east trades. The water banking up against the two large islands then forming the Caribbean Islands must, of course, have been deflected north, have swept round the northern shores of the Virgin Islands, Porto Rico, and Hayti, and poured into the western basin

of the Caribbean Sea, through the passage between Hayti and Cuba. This water being forced into a sort of funnel, by the 500-fathom line forming the southern line of the Great Bahama Island, which connected nearly the whole of the Bahamas with Cuba, and formed a barrier to the western flow of the equatorial current; this must, therefore, for the greater part, have been deflected north, and either swept in a north-easterly direction, as the Gulf Stream now does, or round the north end of the Bahamas, across Florida, which did not then exist, across the Gulf of Mexico, and into the Pacific over the Isthmus of Tehuantepec. To Commander Bartlett's interest in this subject I am indebted for the first information respecting the lines run between the islands:

Extract from Letter of Commander J. R. Bartlett, U.S.N.

"I connected the islands by running traverses across the ridges. From St. Vincent to St. Lucia the ridge was only from 150 to 170 fathoms below the surface, with a channel of 400 fathoms near St. Vincent. The channel between St. Lucia and Martinique had 500 fathoms in mid-channel, sloping upward to each island. The channel between Martinique and Dominica was a tough one, and I thought I should never find a ridge. The soundings increased regularly on a ridge to 300 fathoms in mid-channel, where I got a sounding 883 fathoms, and then 1,000 fathoms; beyond this the ridge was some ten miles to the westward, with an average depth of 400 fathoms, but I found two peaks with only 40 fathoms. The deep water from the Caribbean Sea makes in between Guadeloupe and Montserrat, but I found a ridge of about 300 fathoms connecting Antigua with Guadeloupe. In this channel I also found a peak with only 40 fathoms. I finished up the line connecting Saba Bank with St. Croix. I found the connection perfect, but the ridge has 700 fathoms water on it near St. Croix. There is 1,000 fathoms three miles north, and 1,800 fathoms five miles south of the ridge. I ran a line from Dog Island to White House Shoal, and back to Sombrero. Here I found a channel about ten miles wide with 1,100 fathoms. The temperature was 38° at 1,100; outside 37½° at 1,600; and 36½° at 2,500. I shall run a number of lines from St. Thomas to Sombrero, to be sure that this channel connects with the deep water off St. Thomas. I ran a line of soundings from the south end of Dominica to Avis Island. The soundings were regular at 1,000 fathoms, to within ten miles of Avis Island."

The soundings made by Commander Bartlett, after I left the *Blake*, to determine the ridges uniting the various islands be-

tween Sombrero and Trinidad, show plainly that the cold water of the Caribbean can only come in through the passage between Sombrero and the Virgin Islands, which is about 1,100 fathoms, with a bottom temperature of 38°, while the 500-fathom line, as I have said, forms a gigantic island of all the islands to the south of Sombrero, including Dominica, with a narrow passage of 1,000 fathoms between it and Martinique; the 500-fathom line again uniting into a large spit, as a part of South America, all the islands to the south of it. Thus the bulk of the water forced into the Caribbean Sea has a comparatively high temperature—an average, probably, of the temperature of the 300-fathom line. The cold water of the Atlantic is, however, again forced into the western basin of the Caribbean through the windward passage, and all this through the Yucatan Channel, between Cape San Antonio and the Yucatan Bank. It is, therefore, incredible that with this huge mass of water pouring into the Gulf of Mexico, there should be anything like a cold current forcing its way up-hill into the Straits of Florida, as has been asserted on theoretical grounds. The channel at Gun Key can only discharge the surplus by having a great velocity.

Mr. Garman, who as usual accompanied me, remained in the West Indies after we left the *Blake* at Barbadoes, for the purpose of making collections of reptiles and fishes, with a view of throwing additional light on the former connections of the islands, as I have here attempted to trace it. One of the most interesting of the reptiles we collected is a gigantic land tortoise, found at Porto Rico, differing only in size from the land turtle still found in Trinidad and adjoining parts of South America. It is closely allied to the gigantic turtles of the Gallopagos, and to the fossil land turtles, of which fragments have been described by the late Professor Wyman. These were collected by Mr. A. Julien at Sombrero, in the phosphate beds of the island.

THE GEYSERS, HOT SPRINGS, AND TERRACES OF NEW ZEALAND.

By JOSIAH MARTIN.

[PLATE IX.]

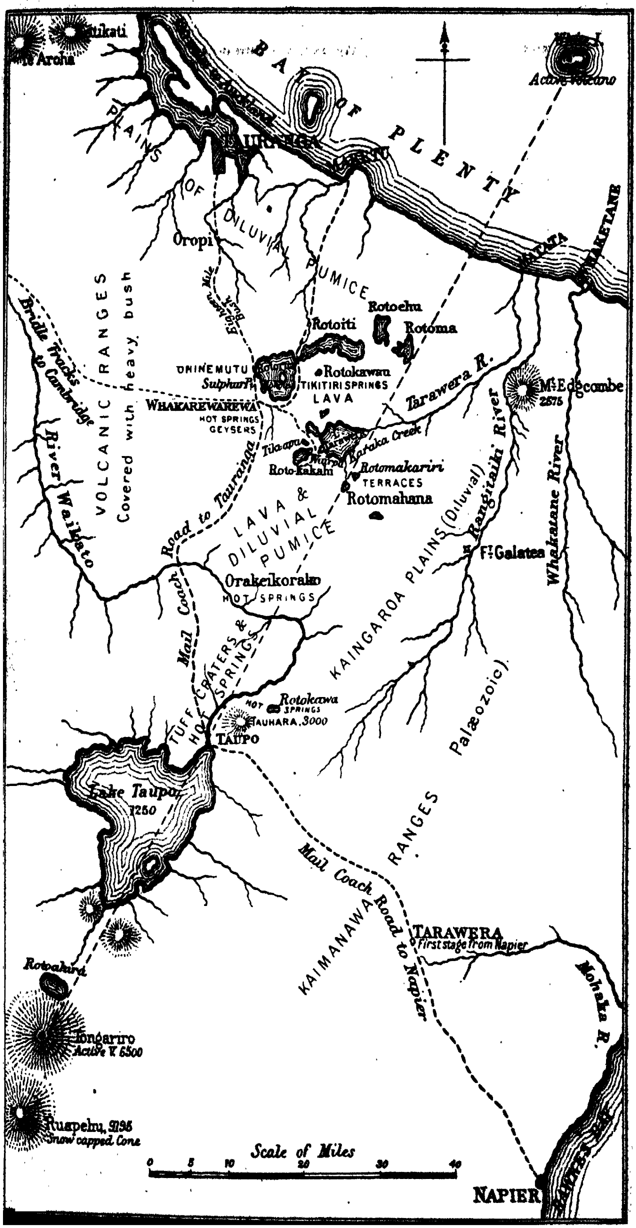
THE islands of New Zealand have been justly celebrated for their remarkable and beautiful scenery ever since the explorations of the illustrious Captain Cook opened up for our nation a second Britain among the waters of the great Southern Seas.

The Alpine ranges, glaciers, fiords, and sounds of the South Island, and the volcanic formations of hot lakes, geysers, boiling springs, active and extinct craters, with the marvellous sinter terraces of the North Island, have excited the wonder and admiration of travellers of every class. The geologist, botanist, and artist have alike been enchanted with the native grandeur and picturesque beauty of our mountains, forests, lakes, and seas.

The line of active volcanic action (see fig. 1) runs in a N.E. direction from the great active crater of Tongariro (which is situated near the centre of the North Island 6,500 feet above the level of the sea), embracing a belt of country about twenty miles on the N.W., to the insular crater of White Island in the Bay of Plenty, a distance of about 150 miles.

In this area is included lake Taupo, and the hot lake districts of Rotorua and Rotomahana; with geysers, sinter terraces, solfataras, fumaroles, mud volcanoes, hot springs and alum caves, in such profusion and of such magnificent proportions and combinations, as to present scenes unsurpassed in any other part of the world.

Tongariro and the district immediately surrounding it are exceedingly difficult of access, the native owners of the property being very jealous of excursionists, in whom they see only political agents, suspected by them of designs upon their territory. But an enterprising artist has lately succeeded in reaching the mountain, and making the ascent; but not without great exertion, and many vexatious hindrances.


BAY OF PLENTY
Te Aroha
Active Volcano
PLAINS OF DILUVIAL PUMICE
Oropi
VOLCANIC RANGES
Covered with heavy bush
Bridle Tracks to Cambridge
Rotoehu
Rotoma
Rotoiti
OHINEMUTU
Sulphur Pt.
Rotokawau
TIKITIRI SPRINGS
LAVA
Tarawera R.
WHAKAREWAREWA
HOT SPRINGS
GEYSERS
Mt. Edgecumbe
2575
Whakatane River
Rangitaiki River
Kaitaka Creek
Tikitapu
Roto-Kakahi
Rotomakariri
TERRACES
Rotomahana
River Waikato
Road to Tauranga
LAVA & DILUVIAL PUMICE
KAINGAROA PLAINS (Diluvial)
Ft. Galatea
Orakeikorako
HOT SPRINGS
Mail Coach
TUFF CRATERS & HOT SPRINGS
HOT SPRINGS
Rotokawa
TAUHARA 3000
TAUPO
Palæozoic
Lake Taupo
1250
KAIMANAWA RANGES
Mail Coach Road to Napier
TARAWERA
First stage from Napier
Mohaka R.
Rotoaira
Tongariro
Active V. 6500
Ruapehu, 9195
Snow capped Cone
Scale of Miles
0
5
10
20
30
40
NAPIER

Taupo District.

Lake Taupo is now upon the main road between Auckland, Wellington, Napier, and Tauranga, and is very easily reached by coach. It has also good accommodation for tourists and travellers, so that this district, and the whole of the country described in this paper, can be visited with comfort, and with no more than the usual difficulties of getting across country roads. Coaches run between the principal towns, and light buggies and saddle horses can be easily procured at Taupo, Tauranga, and Ohinemutu.

Approaching Taupo from Napier, the road passes through lovely forest scenery of hill, valley and gorge, where the man of science and the artist can each find inducements to linger, and to wish for an extension of time in order to "do" the district thoroughly. But we pass on, and as we surmount the last hill and emerge from the bush, a glorious panorama opens before us. Peaks, craters, and basaltic rocks stand out in bold relief above the timber-clothed hill-sides, and seem to strew the valley of Tarawera where the first evening from Napier is spent.

The first view of Lake Taupo is very striking. The wide expanse of water stretches away in the distance, and is lost among mountain shadows, behind which rise the lofty cones of Tongariro and Ruapehu—the former smoking or pouring forth its lava streams, and the latter lifting its snowy peak in silence to a height of 9,200 feet.

As we approach the lake the small clouds seen around its borders, become distinct as columns of steam, and countless hot springs bear evidence to the energy of the volcanic forces which are apparently extinct in the numerous tuff craters around.

The comfortable hotel, stabling, stores, &c., which, with a few other buildings, constitute the *Taupo* township, is prettily situated, but the plains on every side are very barren. The Government have here secured a strip of active springs and bathing pools, but with this exception all this part of the country is in the hands of the Maories. Some shelter has also been provided here for visitors to enjoy the baths without undue exposure to the sun or wind. The ground around is seething with bubbling and boiling springs, and with fumaroles and solfataras of all sizes and at all temperatures; from tiny cups of creamy liquid, to vast cauldrons in trachytic rock, incrusted with glistening crystalline sulphurous deposits; or with siliceous sinter, more or less tinted with ferric oxide.

In this neighbourhood there is a very remarkable geyser cone, which, covering an area of nearly twenty feet in diameter, rises to about six or seven feet; the crater is an oval of six feet mean

diameter, and the basin appears about half-full of bubbling water, about 200° F.; it is built up—like a huge crow's nest—of sticks which are incrusted and cemented with silica; it occasionally breaks out and ejects large volumes of steam, or showers of boiling water. Many ingenious theories have been propounded to account for its singular appearance, but close and continued observation will be required before a satisfactory explanation can be given.

Roto Kawa is a small acid lake in this district, which is approached with extreme caution because of the treacherous nature of the deposits of tufa, obsidian, and pumice, which are broken through by so many hissing jets that, as the soil reverberates to our tread, and the guide repeats his warnings, we confess to a feeling of insecurity, painfully enforced by various reports of unwary wanderers who have fallen through. The ground is insufferably hot to the touch, and here and there we discover yawning chasms of black seething mud from which the vapours of sulphuretted hydrogen, mingled with fumes of sulphurous acid, greatly offend our senses, and painfully remind one of the visionary Gehenna and of its traditional terrors.

Twenty miles from Taupo, and some little distance off from the main road, is the district of Orakei Korako, so ably described by Dr. Hochstetter, where he counted seventy-six jets of steam from one point of observation. The principal geyser of the series is periodically intermittent, throwing up its boiling column about every two hours to a height of from ten to thirty feet; adjoining this is a small sinter basin which forms a luxurious warm sitz-bath—after a few minutes immersion one's skin is covered with a fine deposit of silica of exquisite smoothness. Numerous hot springs on both sides of the Waikato river at this point are highly charged with alum, silica, and carbonate of lime; and these crystallize into forms of great beauty, which are seen to perfection in a deep cavern known as the Alum Cave, in the recesses of which, reflected in the beautiful blue mirror of a pool of warm water, incrustations and stalactites of varied forms and tints delight the beholder.

Recrossing the Waikato we pass through another series of springs and mud pools, with small volcanoes of pink or grey mud; and after a journey of about sixteen miles we cross a hot river which is fed by numerous boiling springs. The luxury of a warm bath *au naturel* can be here enjoyed to perfection; and a spring of delicious cold water will refresh the weary by applications, external and internal. Some of the choicest and rarest of New Zealand ferns are to be found only on the banks of this stream, the humidity of the warm atmosphere being peculiarly favourable to their growth.

Rotorua.

Rotorua is a nearly circular lake of about twenty miles in diameter, surrounded by hills from which the timber has long since disappeared. Near the centre rises Mokoia, a volcanic island, with three conical peaks or craters, and with well-defined terraces which mark a previously higher level of the waters of the lake. Several native wharès or huts, and extensive plantations, are found all round the island, which was in former days a very important fortress, and is still celebrated in Maori legend and tradition. Hinemoa, the maiden, is the heroine of many of their songs and stories. Mr. Domett has immortalized her history in his poem "Ranolph and Amohia;" and Mr. Chevalier had a charming picture of this Maori girl at the Royal Academy.

The seat of active volcanic agency is principally confined to the eastern shores of the lake. A narrow ridge of volcanic clays, rising about thirty feet above the level of the lake, forms the township, where, as at Taupo, the telegraph places us in immediate communication with the business world. On the slope toward the lake is seen the main settlement where the natives spend their time in sensual idleness; the bank of the lake is here perforated with thousands of springs, and these form the cooking places for the tribe; every hut has its boiler worked by nature as close to the door as is deemed convenient; and kits or baskets of potatoes, fish, beef and other edibles are suspended in these pools until ready for table. Over some of the hottest portions of the ground, large slabs of stone are placed, on which, covered by moist grass or weeds, bread is baked; on other slabs, not quite so hot, the lazy recline themselves, and, wrapped or covered with a blanket, enjoy Vulcan's heat on the coldest day.

Several of these springs are celebrated for remarkable cures. Some are reputed to be arsenical, others are sulphurous, and many are impregnated with alkalies. One remarkable pool called by the natives Kuirua (see Analysis No. 3, p. 383), which is fed by numerous hot springs, is celebrated for its saponaceous properties, and is the laundry for the township and settlement. Its temperature varies between 130° and 160° F.; it has a strong alkaline reaction, and clothes are washed here without any artificial admixture of soap or soda.

The natives, who are said to be afflicted with chronic impecuniosity, persistently importune the visitors for gratuities, but under the charge of one of the European residents the tourist is relieved from their presence, and can inspect the exterior of their dwellings without the levy of black mail. The borders of the lake are perforated with numerous springs, and bathing at any

temperature can be enjoyed, and is freely indulged in by natives of both sexes, heedless of the restrictions imposed by the proprieties of fashionable watering places. The little tongue of land on which this settlement stands is quite undermined, and the place is shown where a similar "Kianga," or village, disappeared one night beneath the water, taking all the inhabitants without warning into the yet warmer regions below.

On this slope are some vegetable gardens belonging to the British residents, where fruits, flowers, and all garden products are forced upon a natural hot-bed to a perfection unattainable elsewhere. On the other side of this ridge several very large ponds of water, some about 200° F., are to be seen under their cloudy canopy of steam.

About a mile from this point, on the borders of the lake, is a sulphur point, an extensive plateau of sinter incrusted here and there with crystals of sulphur, where some very remarkable medicinal springs abound, in which some wonderful cures have been effected. (See Analysis No. 7.)

Many invalids, who have been attracted by the world-wide renown of their effects, suffer under great disadvantages from the want of a competent resident authority, and the absence of adequate shelter. Numerous pools are shown, one of which is called the Pain Killer (see Analysis No. 6), but they are merely holes in the ground, or small running streams, which must be cleared out by the visitor to allow of his immersion, and perhaps, directly this has been done, a watchful native takes advantage of the opportunity afforded and steps in first.

A mistake may easily be made in the selection; at one place a boiling and a cold spring, each overflowing from small cisterns of sinter, unite their streams in a third or tepid bath; an invalid on one occasion, intending to use the warm bath, stepped inadvertently into the cold one; the shock was unexpected, and in his alarm it was mistaken for the boiling pool; to remedy his supposed error he jumped into the other nearly up to the middle; his scalded limbs immediately discovered his error, which unfortunately proved fatal. The whole surface adjoining this plateau is incrusted with sulphur; and ponds of various sizes, dark mud holes, yawning cracks, miniature geysers, artificial baths, beautiful basins of bubbling sulphur, thousands of little tiny cups and countless jets of noxious vapours combine the attractive and the repulsive in fantastic profusion.

On the opposite side of the lake are the renowned Tikitiri springs. The columns of vapour which arise from these remarkable eruptions are seen from every part of Rotorua. Geysers are so numerous, and deep spluttering mud holes so abundant, that the spectator is appalled. The largest geyser is about 100 feet in diameter, and boils in billows of great fury,

dense fumes of sulphurous acid arise from the troubled waters, and silver ornaments are speedily discoloured by the dense vapours which are exhaled. (See Analysis No. 9.)

Whakarewarewa, about two miles from Rotorua, is a centre of volcanic activity of great interest to the geologist. The natives will provide huts for the accommodation of visitors, and provisions can be easily obtained. The varied phenomena of the entire district can here be seen in miniature, and as the influence of atmospheric pressure upon the various eruptions and geyser displays can be studied at leisure, some very important investigations may be made at this place with very little trouble or fatigue.

The ground around this point is arid, but within the circle of activity, gardens and orchards display a rich luxuriance. A deep chasm, along which rushes a noisy stream, divides the settlement, the banks on either side being noted for some very remarkable fumaroles.

Through the plantations, and passing several native huts, we come upon a large plateau of silica which reverberates beneath our tread. The temperature of its surface is over 100° F., and a large opening in the centre reveals the fact that we are walking upon a crust of unknown strength and thickness over a large basin of boiling water. Approaching as near as our treacherous foothold permits, we are almost overpowered by the heat and steam. The wind clearing the cloud of vapour, we see Parekihuru, a large hole of about 30 feet in diameter, overflowing with boiling water; fringing the profound azure depths we notice, under the crust on which we stand, beautiful irregular coral-like formations. The excessive heat and the insecurity of our position compel a speedy retreat to a firmer and cooler footing.

Numerous smaller springs, supersaturated solutions of silica, form very beautiful incrustations in a short time, and articles dipped into them are speedily covered with a soft and delicate deposit resembling hoar frost, which is too fragile to bear transport.

Close by is another boiling fountain, rippling over beautiful miniature terraces of pure white sinter which appear like petrified cascades, and falling into a small basin the temperature of which is from 96° to 120° F. (see Analysis No. 2). The stream forms a head of water, and it is artificially conducted by a wooden shoot over the edge of a cold pond, where a patient afflicted with spinal rheumatism can stand upon a mat, and permit the hot water to fall upon his head or back, after which he can easily take a plunge into the cold bath at his feet. Several wonderful cures are attributed to this bath, and a hut has been built by the Maories for the use of visitors.

Several mud holes of different degrees of activity and consistency present some beautiful examples of the formation of concentric rings, miniature craters, radial fissures, and annular combinations produced from several centres which will form a very interesting subject for closer investigation. Here are a few intermittent geysers which require to be teased into activity, and sods thrown into them will be ejected with great violence; some small cavities, which apparently are perfectly harmless, suddenly start into activity, and are so uncertain in their action that they are dangerous to approach without a guide. Numerous baths to which fancy names have been given, are used by natives from all parts of the island for rheumatic or cutaneous diseases, and one is used as a cure for syphilis. An alkaline spring called the oil bath (see Analysis No. 4) is much resorted to by both Europeans and natives.

Upon a higher elevation by the side of a hill of decomposed rhyolitic rock we cross another siliceous plateau with several geysers in all stages of activity. Some are furious in their ebullition; the most interesting being the famous Wakiti, a huge sinter cone built up of beautiful white circular terraces diminishing from one hundred feet in diameter at the base to about three feet at the summit. The apex of the cone is about thirty feet above the plateau, and can be easily reached. A small quantity of steam issues from the funnel, which is a narrow opening, and a deep rumbling can be heard from beneath; but occasionally it throws up a column of water to a height of eighty or even a hundred feet. The natives state that in certain seasons this geyser is very active, and all the smaller ones around play in concert. It is influenced, they say, by the direction of the wind, but whether under a high or low atmospheric pressure has not been observed. We may here recommend intending visitors to secure the services of a European guide from Ohinemutu. Mr. Henshaw accompanied our party, and rendered us very material assistance; but on another visit without his protection we were seriously annoyed by the importunities of the residents, and could not gain access to this, the most important centre of Whakarewarewa, as we refused to satisfy the exorbitant demands made upon our exchequer.

Tarawera.

From Ohinemutu we start on saddle horses, or light American buggies, for Tarawera and Rotomahana, and after a ride of twelve miles arrive at the picturesque settlement of Wairoa, where comfortable accommodation can now be obtained at very reasonable charges. The road has recently been opened and

widened; the ascent from Rotorua passes through several cuttings, made in the decomposed trachyte and diluvial pumice, which, with deposits of obsidian, form the surface of the entire volcanic area. The retrospect over the lake, with its numerous steam clouds, is very fine; but the road through Tikitapu bush will at once attract the attention of every lover of the picturesque; the botanist and entomologist would rejoice to spend days or even weeks in this lovely grove; and when the blue waters of the lake are discerned through the overhanging foliage an expression of delight escapes from every beholder.

Encircled by steep hills, and clothed with luxuriant foliage to the water's edge, this enchanting and at one time inaccessible lake, perfectly reflecting from its azure surface and transparent depth the dense vegetation of its borders, forms a picture of which we have never seen the equal in the Old World or the New. With no visible outlet, the cold blue water of unknown depth always maintains about the same level, and as our "buggy" rolls along the cutting of pumice on its border, we regret that we cannot linger to enjoy its fairy beauty. Ascending, we cross a narrow ridge and look down over another lake—Rotokakahi—at a much lower level, of pale green water, from which, by a subterranean outlet and by a succession of pretty cascades, it reaches Wairoa and falls into Lake Tarawera. Following this stream we arrive at a comfortable hostelry; and at a spot once famous for its miserable accommodation we find a well-furnished hotel.

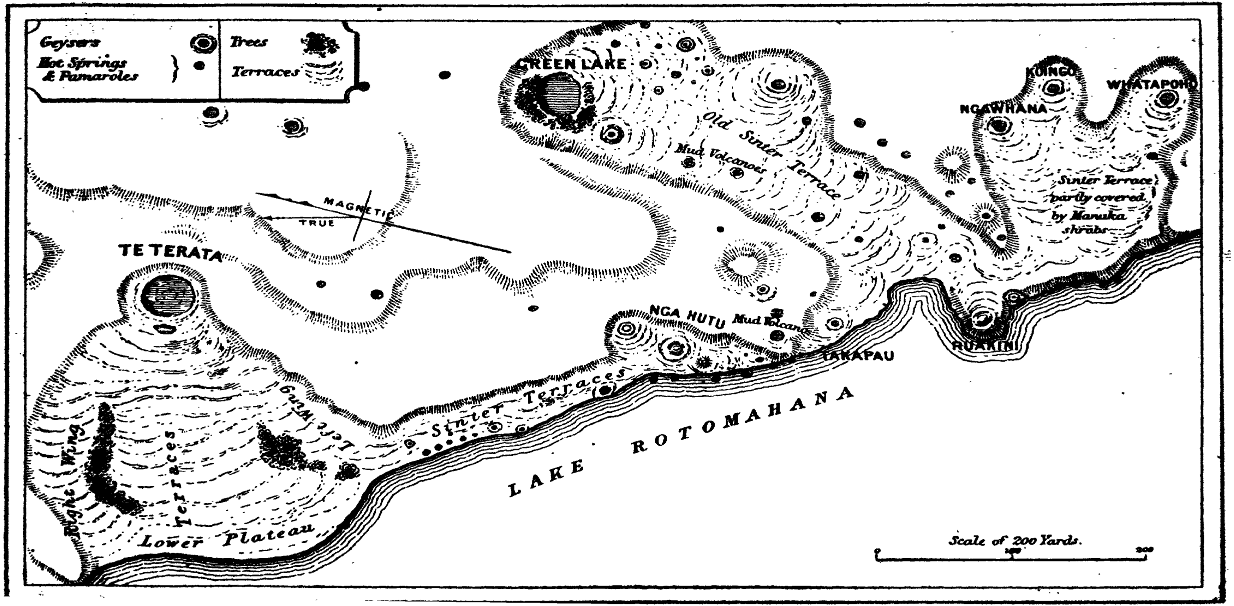
The natives have now several commodious whale boats (for there stretches eight or ten miles of lake between us and Rotomahana), which replace the old canoes that were so formidable to travellers unused to this mode of transit. Fixed charges are now made by the Maories, but a tribute of £5 is exacted from every photographer or artist who may wish to carry away anything more than mental impressions of the scenery; and the removal of specimens is also prohibited, and with good reason. A fine opportunity is afforded for the contemplation of human nature as exemplified in the aborigines, who are very intelligent, and are more industrious than at Rotorua. Their propensities to appropriation are strong; and they have also a marked appreciation of beer or spirits.

The row or sail along this lake is very delightful. It is 1,075 feet above the sea level, and is surrounded by volcanic hills, the largest, Tarawera, rising about 1,000 feet.

Rotomahana.

Our boat lands us at the mouth of the Kaiwaka creek, where, after paying half-a-crown per head for admission fee and five

FIG. 2.—SKETCH MAP OF THE SINTER TERRACES, GEYSERS, FUMAROLES, AND HOT SPRINGS ON THE EASTERN SHORE OF LAKE ROTOMAHANA.



or ten shillings for hire of a canoe on Rotomahana, we make our way past several hot springs and steam jets, and from the top of a small hill catch sight of the dull green water of Rotomahana, fringed with sedges and rushes, and surrounded by barren hills of no great elevation. The terraces and geysers which have made this lake one of the wonders of the world are only indicated by columns of steam, which are rising on every side.

We descend and pass through patches of manuka, or Ti tree scrub, and then standing upon the dazzling white platforms of Te Terata, we are silenced by the resplendent beauty of the scene which bursts upon us (see fig. 2 and Pl. IX. fig. 2).

Sensations and emotions unknown in our previous experience completely overpower us, so that we are unable to describe our impressions in ordinary language, or even to recall them to our memory with vivid distinctness. This wonderful structure has been formed by a geyser of the greatest force and volume, which, bursting forth from the base of a hill of volcanic clays and decomposed lava, has gradually elevated and enlarged its beautiful basins, and, building up terraces and buttresses of unparalleled natural beauty and design by its own siliceous deposit, has retired further and further into the side of the hill, which now overhangs the reservoir with a circular wall, almost perpendicular. As we ascend the delicate stairway, we are almost dazzled by the sublime effect produced upon our senses. We found the use of neutral tint or blue spectacles a great advantage to tone down the absolutely overpowering splendour of the scene.

Every tier reached in our upward progress reveals new combinations and effects. The grand design of the whole is the same everywhere; but the detail is essentially distinct in every part.

As we reach the culminating ridge of the terrace, and review these magnificent gradations spread out fan-like before us, we begin slowly to appreciate their beauties and to understand something of their structure. We count forty distinct platforms or terraces of varied form, but similar character, with numerous basins, resembling the purest alabaster, all filled to overflowing with sapphire, turquoise, or azure waters which trickle over and incrust the edges of their reservoirs and drape them with festoons of sinter.

So very numerous and varied are these baths and fountains, platforms and steps, that we should delight to spend weeks in their neighbourhood, and devote each day to the discovery of some new manifestation of nature's architecture, decoration, and design.

The hill itself seems crumbled and undermined by active volcanic agency, and presents a most interesting field for the student of vulcanology. Several old craters may be traced in

the contour of the hill, and the countless fumaroles, solfataras, and geysers bear witness to the enormous activity at work beneath. The surface is everywhere warm to the touch, and its foothold is treacherous in the extreme; and further evidence of activity may be obtained by a tour of inspection over the ridge, where a puff of steam rises from the soil as it crumbles beneath our tread, and very thick soles are necessary to protect our feet. The hill from which this geyser rises covers an area of about 1,000 yards by 500. It slopes on the s.w. into Rotomahana, or the Warm Lake, and on the N.E. into Rotomakariri —the Cold Lake.

The great basin of Terata is situated at a height of nearly eighty feet above the level of the lake, and 300 yards from the outer edge of the lowest terrace (fig. 2). The reservoir is nearly circular, of about ninety feet diameter, and of a depth variously estimated at from twenty to forty feet. It is nearly surrounded on its inner side by a lip or edge, about six feet wide. Through the dense overhanging steam, the deep azure water of the cauldron may be seen (see Analysis No. 1). It is always hissing and boiling, and possesses a temperature varying from 210° to 214° F., according to its activity. It is so quiet at times that a daring adventurer can walk around its lip, or even descend a few feet into its nearly empty basin; but it will suddenly, and with terrific violence, break into activity, and, throwing up an enormous column of water, fill its basin to overflowing, and perhaps forcibly eject the whole contents in one convulsive eruption, throwing the water to a height of forty or fifty feet, to the certain destruction of any one who has dared to come within reach of its scalding fountain.

Two-thirds of the basin is enclosed by the hill-side, and an island of harder rock stands midway in the opening. This affords shelter for the spectator, as well as an elevated position from which to observe the eruptions or to view the terrace.

The siliceous deposit which forms the terrace extends from the lip or edge of the basin over a large plateau, and then descending in three sections, forms a lower plateau, which has a frontage to the lake of about 200 yards.

The upper plateau receives the very newest deposits, and resembles a small field of ice covered with a few inches of snow. The spectator feels that it is almost sacrilege to tread upon and crush this beautiful crystallized frost-work. The sun's rays, decomposed by these delicate crystals, with sparkling iridescence glisten in fairy splendour. Below the beautiful curves forming the edge of this plateau, and sloping outwards, are rounded masses of snow-like sinter; below these again are several pools of hot water of the richest cobalt hue, or sparkling like sapphire, which, reflecting the overhanging festoons, light them with deli-

cate azure tints; and then another plateau is reached, formed of rippled layers of hardened silica, frosted with recent incrustations.

The formation here divides into three sections: the centre or terrace proper, and the right and left wings; and before reaching the lake these sections are separated by clumps of foliage growing upon the natural soil, but are re-united in the lower plateau.

(*a.*) The central section is the oldest formation, and is built up of (1) huge overhanging buttresses, tattooed or carved into delicate lines, and festooned with incrusted pendent points, from which the water occasionally drips. (2) Terraces, rising tier above tier, of various thickness, but all perfectly level, the edges and faces of each step being rippled or chiselled into lines like the shadows on a woodcut, several grades together appearing like a petrified cascade.

(3) Basins. Near the upper plateau are several basins whose overhanging lips drop the slowly cooling liquid into other basins below. Evaporation is slowly silting up the basins; but at the same time raising and thickening the outer rim. Where some accident has broken through the brim, the increased flow at this point builds up smaller steps of similar form, and at last the broken part is cemented to its original level.

(4) Cups. On the lower terrace tiers, thousands of small cups are formed, all bearing the same characteristic sculpture which gives the name of Te Terata, or the tattooed rocks.

The evident tendency of the whole deposit is to form (5) slopes, which are seen in various stages of transition from the terraced stairway to the even slope which follows the medial line of obliquity. These slopes are very beautiful, as in them can be seen the gradual filling up of buttresses, terraces, and basins, and the ultimate reduction of the whole at some distant date. Some of these slopes are more rounded and steeper than others, but all present the same rough surface; and a passing shadow, or the rays of the setting sun, illuminate these prominences with pleasing effect.

In the central section, and immediately above the lowest plateau, are several tiers of cold-water basins, low and shallow, but discoloured and mottled by confervoid growth. The water in these basins is of a greener tint, and contains a perceptible amount of lower vegetal life. The middle of this central division is broken by an irregular deposit of a different character, apparently caused by some obstruction—a prominence bearing a fancied resemblance to a "boar's head" is formed, and the terrace steps are rounded and broken.

(*b.*) The right wing is an irregular slope broken into steps in several parts of the descent, and containing a large quantity

of sticks, stones, and clumps of soil projecting above the sinter, but all are incrusted more or less with silica. No regular basins are seen in this section, but, where an obstruction occurs, small terraced ridges are formed.

(*c.*) The left wing (looking downward) has similar characteristics; and as the stream, after depositing the silica (held in solution by great subterranean pressure) on the upper or snowy plateau, makes its way over the slope of the hill and among shrubs and grasses, the new deposit, caused by the slow evaporation, spreads its snowy mantle over the soil; the scarcely concealed foliage and mosses sparkle and glisten, but, if gathered, their frosted incrustation speedily falls off. Where the siliceous deposit is indurated and hardened, their forms or outlines may be traced long after the vegetation has disappeared, but we were unable to discover any true petrifactions. The most recent overflow finds its way over this wing, but the tendency is to form incrusted ridges and slopes, and not cups, basins, or terraces. The evidence is strongly in favour of the theory which supposes the central reservoir to have been originally at a lower level and nearer to the edge of the lake, the deposit of sinter having elevated the reservoir and causing it to retreat along the path of least resistance into the side of the hill.

The lower platform is the most extensive, and may be estimated at about one hundred and fifty feet in width, while it has a frontage of about three hundred yards along the edge of the lake. Its surface is in rippled layers, discoloured in many places, and supporting patches of scrub, fern, or moss upon a thin stratum of soil of recent deposit. Its general appearance is that of a pavement of concrete which has been subjected to the action of water overflowing from the lake. From our hasty review we could gain no idea of the thickness of the deposit in any place, but some enterprising geologist will doubtless spend a long vacation in this region and give the world the benefit of his investigations.

Leaving Terata, and passing again through ti-tree scrub, we examine more closely the southern portion of this remarkable volcanic hill. The smaller fumaroles escaping notice, our attention is arrested by two immense geysers (see fig. 2), Nga Hutu, which occasionally works great wonders, and Kakarike, which is truly appalling, its huge cauldron (about 50 feet in diameter) rolling in boiling waves, which break against its side and dash upward in angry menace. Passing several hot springs on right and left, a terrific roar breaks forth from a deep recess at some distance, caused by an escape of steam in great volume at enormous pressure. Subterranean rumblings and noxious exhalations combine to form a sensation the most perfect antithesis to

our experiences on Terata. Tophet must have been a paradise to this spot; and if Dante could have visited Rotomahana, what fearful horrors would have been suggested to his vivid imagination.

Across a platform of hot stones and the remains of an old sinter terrace broken up by the shifting soil, we find a geyser, once furiously active, now nearly extinct, and so quiet that it is used as a favourite cooking place by the natives, who dare not venture too close to the more terrible of the group.

In a deep hollow of forbidding aspect are several mud holes ejecting an edible acidulated mud. We declined a meal upon such dainty fare, but one hole was suggestive of a giant's porridge pot. The rising of bubbles, the annular eruptions, and the effects of volcanic discharges in plastic clay forming ridges and rings, would be interesting to a student of selenography. From hasty observation we failed to trace any distinct resemblance to lunar craters.

The green lake, a pool of pea-green water, is a striking contrast to the prevailing character of the scenery. The water is deep and cold, slightly acidulated; but we are not aware of any analysis to account for its remarkably verdant colour. The border of the pool shades into blue, and its level is reported to be unaltered.

There used to be a small steam-whistle, but some inquiring tourist, emulating the famous juvenile experiment upon the domestic bellows, inserted his walking-stick into the narrow vent and effectually stopped its music.

There are several wharès or native huts on this point and on two small islands in the lake, but they have been long since deserted except by rats and fleas; the ground is so honeycombed with boiling springs that it must be very dangerous for occupancy. In one of these deserted huts we found luncheon prepared; our potatoes and kaura (small cray fish) had been cooked in one of the natural kettles, and we found that Bass's pale ale was not to be despised, although at a cost of 2*s.* 6*d.* per bottle and a porterage of many miles.

Otakapuarangi—the Pink Terrace (Pl. IX. fig. 1).

A native canoe ferries the visitor across the lake to the foot of the Pink Terrace, which is seen rising in fairy beauty, tinted as with rosy sunset hues, and like its paler sister broken into about fifty distinct terraces and cascades of varied height and form. Enclosed in a horse-shoe curve of the hill this formation becomes much narrower at its embouchure on the lake.

Ascending the steps, the observer is struck with many points of resemblance to Terata, and also with essential points of difference.

1. The surrounding hill is of harder and firmer rock, and but few other springs are seen, and these are confined to the base of the hill. The summit is gained with ease and safety, and a magnificent and unequalled panorama of the whole is seen; it expands to greatest width in mid-descent, and narrowing at its fringe. The deep blue of the reservoir and basins form a very pleasing contrast to the fresh pink of the upper and newest formation. This colour is lost nearer to the lake, and the lowest lines resemble those of Terata.

2. The geyser is a little smaller than Terata and is more open; its deep azure water, although constantly boiling and steaming, overflows quietly and, covering a pavement like alabaster, falls over (3) the upper plateaux, on which are inscribed the names of tourists and the dates of their visit. These slabs are perfectly smooth, and inscriptions in pencil become indelible under a coating of silica in a short time; but upon examining dates of twenty or thirty years since, the deposit or film was so thin as to be scarcely perceptible except as a thin glaze. (See Analysis No. 5.)

4. The basins. There are five basins used for bathing pools, and presenting the most luxurious bath that can be imagined. The temperature is graded as the baths, and the inner surface has a soft feeling like satin or velvet.

5. The overflow here divides; finding a new channel to the right, it leaves the old formation and carves out for itself a new course which it covers and decorates with its peculiar deposit. The old formation resembles Terata in its overhanging buttresses, its engraved or tattooed festoons, and its stalactite fringes.

6. The new formation is a cascade of unmatched beauty; the stream leaps from rock to rock, forming rounded masses and slopes of pink sinter, but no distinct terraces are seen until the new stream flows once more over the older at an elevation a little above the lake.

The evidence of these distinctive features seems to indicate a period when the Pink Terrace was, like Terata, discharging under high pressure; and comparing the two terraces it is evident that the frosted incrustations and snow-like deposit upon the upper platform of Terata, are due to the sudden deposit of sinter hitherto held in suspension by enormous pressure. The smoothness of the floor of the Pink Terrace, and its marble inscription slabs, is caused by the slow evaporation of the water in its constant overflow. A trace of oxide of iron in the analysis of the water and of the sinter sufficiently indicates the source of its prevailing tint.

Under certain conditions of wind or weather, this geyser is said to cool down and its outflow to cease, but systematic investigation is needed to decide the conditions of such irregularity.

Immediately to the left of the Pink Terrace is a large solfatara, presenting in opposite extreme the most extraordinary features. Literally a lake burning with fire and brimstone, it is awfully suggestive of Tartarus, and although its repulsive character is attractive we must not linger in our description.

On the western shore of Rotomahana there are five or six other basins of boiling water of lesser magnitude. The waters of the lake vary in temperature, but it is saline in all parts except the north-west corner, and here as our canoe is pushed in among the sedges the Maori boy dips up a supply of cool fresh water, sparkling and clear.

The return journey by canoe takes us through the narrow rapids of the Karaka creek, where hissing steam-jets and mud holes line the banks. At Tarawera we re-embark, and stimulating our Maori boatmen with *promises* of good cheer when we reach the hotel, we make rapid progress to Wairoa. The return journey will be made *viâ* Ohinemutu, and through the "eighteen miles bush" by good but irregular coach road, forty miles to Tauranga, a beautiful harbour on the Bay of Plenty.

ANALYSIS OF MINERAL WATERS.

By Prof. W. Skey, Analyst to the Geological Survey of New Zealand.

(*From the "Transactions of N. Z. Institute,"* 1877.)

1. *Te Terata, Great Geyser of Rotomahana.*

	Grains per Gallon.
Silicate of soda	68·48
Monosilicate of lime	1·62
" " magnesia	·53
" " iron	·51
Sulphate of soda	7·84
Chloride of potassium	2·87
" " sodium	62·61
Phosphate of alumina	traces
Lithia	"
	144·46

All but soda are monosilicates; the little excess of silica, 7·66, is included in the soda silicate.

2. *Medicinal Springs at Whakarewarewa.*

Silicate of soda	16·32
„ „ lime	1·61
„ „ magnesia	1·14
„ „ iron	·39
Sulphate of soda	13·47
Chloride of potassium	1·24
„ „ sodium	53·61
Phosphate of alumina	traces
	87·78

3. *Kuirua, or Saponaceous Spring, Ohinemutu.*

Monosilicate of soda	2·57
„ „ lime	·34
„ „ magnesia	·12
„ „ iron	·31
Sulphate of soda	10·31
Chloride of potassium	2·08
„ „ sodium	45·70
Phosphate of alumina	traces
Silica, free	18·42
	79·85

4. *Caustic or Oil Bath, Koroteoteo, Whakarewarewa.*

Monosilicate of soda	2·08
„ „ lime	3·16
„ „ magnesia	·76
„ „ iron	·85
Sulphate of soda	7·49
Chloride of potassium	1·46
„ „ sodium	66·34
Silica, free	22·40
	104·54

Water distinctly alkaline or slightly caustic.

5. *Pink Terrace, Rotomahana.*

Silicate of lime	1·91
„ „ magnesia	1·16
Chloride of potassium	1·05
„ „ sodium	93·55
Sulphate of lime	10·96
„ „ soda	1·01
Alumina phosphate	·54
Silica, free	43·95
Iron oxides	traces
	154·13

Temp. 204° to 208° F.

6. *Sulphur Bath, Ohinemutu, "The Pain-killer."*

Sulphate of potash	2·98
" " soda	34·37
Chloride of sodium	59·16
" " calcium	3·33
" " magnesium	1·27
" " iron	·25
Phosphate of alumina	traces
Silica	16·09
Hydrochloric acid	7·60
Sulphuretted hydrogen	2·01
	127·04

(7.) Te Kauwhanga Mud Bath, 1¼ mile from Ohinemutu. Thick brown muddy water, covered with oily slime; temperature 80° to 100° F., depositing a heavy muddy sediment; has persistent acid reaction and an offensive odour.

(8.) Ariku-Kapakapa, 2 miles from Ohinemutu. Small pool; strong outflow; temperature 160° F., depositing sulphur; reported to have powerful curative properties.

(9.) Te Kute, Great Spring of Tikitiri. Temperature 100° to 212° F.; muddy brown, containing a large proportion of sulphuretted hydrogen; reported wonderfully efficacious in rheumatism and cutaneous diseases.

	7.	8.	9.
Sulphate of potash	·77	·38	·59
" " soda	23·71	12·51	12·66
" " alumina	1·46	·68	11·22
" " lime	2·04	2·21	1·01
" " magnesia	1·62	1·29	·69
" " iron	1·47	3·15	1·73
Phosphate of alumina	traces	traces	traces
Sulphuric acid, free	7·60	13·95	·77
Hydrochloric acid, free	7·66	2·62	1·63
Sulphuretted hydrogen	3·19	—	5·74
Silica	13·86	18·15	12·40
	66·38	54·94	48·44

EXPLANATION OF PLATE IX.

FIG. 1.—Otakapuarangi—General view of the Pink Terraces, Rotomahana—from the Sulphur pool.

FIG. 2.—Te Terata—View of the cold-water basins on the White Terraces, Rotomahana.

(From Photographs by Burton Bros., Dunedin.)

Fig. 1. PINK TERRACES, ROTOMAHANA.

Fig. 2. WHITE TERRACE, ROTOMAHANA.

Mintern Bros lith.

THE MOST POWERFUL TELESCOPE IN EXISTENCE.

BY E. NEISON, F.R.A.S.

WHICH is the most powerful telescope in existence? Define the meaning which ought to be attached to the adjective "powerful" in this question. The most powerful telescope in existence is that existing telescope which can do the most work. The work of a telescope may be said to be to enable you to see and to enable you to measure. Therefore, that telescope with which you can see most and can measure best, is that which can do the most work, and is unquestionably the most powerful telescope in existence.

Which is the most powerful telescope in existence?

Everyone has heard of the two giant telescopes which were constructed nearly forty years ago by the late Lord Rosse, and which were erected at his residence at Parsonstown, about fifty miles from Dublin. The first great telescope constructed by Lord Rosse was a reflecting telescope with a speculum three feet in diameter and twenty-six feet in focal length. It was carried in a ponderous tube moving in a massive iron mounting by means of ingenious machinery. When it was finished in the year 1840 it was considered the grandest instrument in existence, and from its employment in the study of the heavens enormous advantages were expected to be gained for astronomy. Scarcely, however, was this telescope out of the hands of its maker, than Lord Rosse resolved to construct a second telescope of still larger dimensions. With enormous skill, patience, and ingenuity Lord Rosse carried out this intention, and by the year 1846 had finished his second grand telescope, the instrument commonly known as "Lord Rosse's Telescope." It has a metal speculum six feet in diameter and fifty-four feet in focal length. This enormous mirror, which weighs nearly four tons, is placed in a great tube eight feet in diameter and fifty feet in length, and this tube is carried by a massive iron mounting supported by two lofty castellated buildings, each nearly sixty feet in height. The weight of the telescope and its mountings is enormous. By

ingenious methods the observer who is using the telescope is placed in a kind of cage, suspended in the air from the mounting of the telescope and carried up and down along with the instrument.

To this day this giant telescope of Lord Rosse's retains its position as the greatest telescope in existence. In its enormous size it has still no rival, in its massiveness and weight it is long likely to retain its preeminence.

Which is the most powerful telescope in existence?

Lord Rosse's giant telescope, of course will be the answer of most people; it will be the answer of the great majority of scientific men; it would be almost the unanimous answer of the British Association, of that Section A which is supposed to keep the world informed of the great achievements of astronomy and of optics.

Is this the true answer?—No.

To most people, to most scientific men, this answer will come like a shock, for to them it has long been a cherished tradition, an article of faith, almost an axiom, that Lord Rosse's giant telescope was the most powerful telescope in existence. To those astronomers who are observers, astronomers not stargazers, it is well known that for years this giant telescope of Lord Rosse's has been beaten in power by far smaller and more compact rivals. In fact, it is doubtful whether in real power it is much superior to its smaller companion, the three-foot telescope.

There are many who judge a telescope by its size alone, who compute its excellence by aid of a two-foot rule and a knowledge of its cost in pounds. With them a telescope with a metallic speculum weighing four tons and measuring six feet in diameter, with a tube fifty feet long, and costing a thousand pounds, ought to give so much light, have such and such separating power, and show this or that object. It is true with small telescopes a great deal may be done in this way, but experienced observers know that the real power of a telescope can only be ascertained by a study of what it has done. Tried by this test, the giant telescope of Lord Rosse breaks down. It has not the accuracy of definition which constitutes the real power of a telescope, for it is mainly upon this that depends its capability for doing work. Compared with the metal specula which were made at the time when Lord Rosse's telescope was constructed, the great speculum of Lord Rosse's instrument might come out with credit. But great improvements have since then been introduced into the manufacture of reflecting telescopes, and the present silver-on-glass reflecting telescopes successfully rival the finest achromatic telescope in definition and in power.

In days gone by repeated reference was made to the wonderful things which could be seen upon the surface of the moon with these two giant telescopes of Lord Rosse's. Picturesque descriptions were given of the minute features which were visible, amazement was often expressed at the small objects which could be seen. Still more interesting accounts were given of what *ought* to be visible,—a carpet of pronounced pattern as big as Lincoln's Inn Fields, the Castle at Dublin, the Courthouse at Cork, a house, or even a man, provided he were big enough. All these *ought* to be seen if they happened to be on the lower surface. Yet when we come to consider what it really is which is described as being seen, when we calmly examine the various drawings which have been made by the aid of one or the other of these great telescopes, then we find that they show nothing which cannot be distinctly seen and drawn by the smallest astronomical telescope of high excellence. An enormous blaze of light is gathered by the telescopes, but all this light reveals nothing which cannot be seen with far greater ease in a far smaller telescope. There are in existence a number of drawings of the planets, and observations of their satellites; there are also observations of close double stars, or faint companions to bright stars, all made with one or the other of these two telescopes. Yet nothing has been seen which is beyond the power of a good astronomical telescope of comparatively moderate aperture. It is only in observing the dull ill-defined nebulæ that Lord Rosse's great telescope has any exceptional advantage, though even in this respect it is probably much overrated. As an astronomical telescope either of Lord Rosse's telescopes would be fairly beaten by either of the fine eighteen-inch reflectors which are now in existence.

If, then, Lord Rosse's great telescope is not the most powerful in existence, what answer is to be given to the question with which we commenced? Which *is* the most powerful telescope in existence? There are the great refractors of Pulkova and of Cambridge, U.S., each of fifteen inches in diameter and 23 feet in focal length. There is the still larger refractor of Chicago with an aperture of eighteen inches and a focal length of 23 feet. All these instruments are of high excellence in defining power, the essential point where Lord Rosse's breaks down. There is the reflector of Mr. Lassells, with its metal speculum of two feet in diameter and its tube twenty feet in length. There is the great Melbourne reflector, with its great metal speculum of forty-eight inches in diameter, the second largest telescope in the world, but by no means so sharp in definition as might be desired, so that it failed to reveal the satellites of Mars which were seen with an instrument of not one-sixth the diameter in Europe.

There is also the great reflector of the Paris Observatory, with a silver-on-glass speculum nearly four feet in diameter, an instrument whose power is seriously injured by the imperfect definition arising from the flexure of its thin speculum. There is also the large refractor constructed for Mr. Newall, of Gateshead, with an object-glass twenty-five inches in diameter mounted in a tube nearly thirty feet in length.

But all these instruments must yield the palm to the great refractor of the United States Naval Observatory at Washington, a splendid instrument, with an object-glass twenty-six inches in clear aperture and 33 feet in focal length. This magnificent instrument is equatorially mounted and driven by clockwork, so that it is complete as an astronomical telescope. The Washington refractor is, however, not merely a telescope of great dimensions; like more than one of those previously mentioned, it is an instrument of high optical excellence. Its definition is crisp and sharp, and it brings every ray of the enormous amount of light which it collects to a sharp focus as a very minute point, so that none is wasted. It was with this fine telescope that Professor Asaph Hall made his famous discovery of the satellites of Mars, that Mr. Burnham discovered a number of the most minute companions to the brighter stars, and that Professors Newcomb, Holden, and Hall have observed and measured the smallest satellites of Saturn, Uranus, and Neptune. It is this magnificent instrument which is supposed by most astronomers to be the most powerful telescope in existence. Then our answer to the question with which we have commenced ought to be—the great refractor of the Washington Observatory. No!

Then which is the most powerful telescope in existence?

The most powerful telescope in existence is the magnificent new reflecting telescope which has been just finished by Mr. A. Ainslie Common, and is erected at his residence at Ealing. This telescope has a silver-on-glass speculum, 37½ inches in diameter, and a focal length of just over twenty feet. It is equatorially mounted in a novel but most efficacious manner, and is driven by a powerful clock controlled in an ingenious manner by a method invented by Mr. Common. This new telescope, which has only been finished about a month, has turned out a great success, and is unquestionably the finest and most powerful telescope which is in existence.

For the last three years Mr. Common has had in his observatory a fine silver-on-glass reflector with an aperture of eighteen inches and a focal length of nearly ten feet. This telescope was mounted by him on an equatorial stand of his own design, on what is known as the "Sissons" principle. For efficiency, power, and excellence this eighteen-inch reflector is as yet without

a rival in England, and was only beaten perhaps by the great refractor of the Washington Observatory. With this instrument was made a number of observations of the faint satellites of Saturn and Uranus, which rendered the Ealing Observatory a familiar name to all astronomers. When, in 1877, the astronomical world was electrified by the announcement of Professor Asaph Hall's discovery of the two satellites of Mars, it was to Ealing that astronomers looked for systematic observations of these faint objects, and it was from Ealing Observatory that came the only systematic series of measures of these objects which has been furnished by England. Astronomers may congratulate themselves, therefore, upon this new telescope being in good hands, and in an observatory where it will not be allowed to rust in idleness like so many of the finest instruments in England.

Satisfied from the performance of his eighteen-inch Newtonian reflector that it would be possible to successfully construct much larger instruments of this kind, it seems to have been about two years ago that Mr. Common first seriously thought of constructing a very large reflecting telescope with a silver-on-glass speculum. It was obvious that this would be a serious undertaking, and one which would require much thought and ingenuity to carry it out successfully. Many difficulties would require to be boldly faced and successfully overcome. The expense alone would have been sufficient to deter most men. Experience, skill, courage, perseverance, money; all would be required if success was to be won.

It was decided to first undertake the manufacture of a telescope with an aperture of 37½ inches and a focal length of about eighteen or twenty feet. This was a much shorter focus than had usually been thought essential for an instrument of this large aperture. Generally instruments of this kind are made with a focal length of from nine to ten times their diameter. This would correspond to about thirty feet focus for a speculum of the given size. The fine performance of his eighteen-inch telescope had convinced Mr. Common that it was not necessary to give a greater focal length than fifteen or sixteen feet. But there were two conflicting interests to be reconciled. The shorter the instrument the easier it would be to mount, and the easier to observe with; but, on the other hand, the longer the focus the better it would be for taking photographs of the heavenly bodies, and this last was one of the main uses that the new telescope was intended for. With the view of best reconciling these two views the instrument was designed with a focus of some twenty feet.

The very first step to be taken was to undertake the manufacture of the glass speculum, and here at the outset an

enormous difficulty presented itself. To make a speculum of the required dimensions it was necessary to have a disc of good crown glass about thirty-eight inches in diameter and from six to nine inches in thickness. Well, purchase such a disc; or rather, as it was not likely that such a thing could be bought ready-made why, order one. This seems feasible enough. But there was not a firm in England who would undertake to make such a thing. In fact, at the time, the opinion was freely expressed that such a thing could not be made. This was a serious obstacle, for nearly all the glass used for optical purposes came from England. Determined not to be baffled, Mr. Common applied to a French firm, and they produced the disc of glass which was essential before a single step could be taken. The first difficulty was faced and overcome.

After mature consideration the grinding and polishing of the speculum into which this glass disc was to be turned was entrusted to Mr. G. Calver, of Widford, a well-known maker of glass specula. From its enormous size, over twice as large and ten times as heavy as any speculum which had ever been manufactured before, it was necessary to construct new and more powerful machinery and even a new building. Nothing daunted, however, Mr. Calver agreed to do his best to turn this great mass of glass into an excellent speculum, though of course he could not guarantee anything, the entire risk necessarily remaining with Mr. Common.

This settled, the greater portion of the task remained to be faced. Given a speculum of the specified size, how was it to be mounted, and how was it to be used. Firstly, the glass speculum must be mounted with such care that, despite its enormous weight, it must nowhere bend by as much as one ten thousandth of an inch. Secondly, the glass speculum and the iron cell which supports it must be fastened at the end of a tube some twenty feet in length, and this tube must be supported by an elaborate mounting by which it can be pointed to any desired part of the heavens, and moved by clockwork so as to follow the apparent motion of the celestial bodies. Thirdly, arrangements must be made so that an observer can always use the telescope, and be enabled to look through the eyepiece of the telescope whatever position it may be in—no slight task, seeing that the said eyepiece must in some positions of the instrument be over twenty feet from the ground. Lastly, the telescope must have an observatory which will shield it from the weather, and yet permit any part of the heavens to be examined with the telescope.

When the instrument has a metallic speculum, like the large reflecting telescopes of Lord Rosse, and Mr. Lassells, and that at Melbourne, it is much easier to satisfy the first condition than

when the speculum is made of glass; for it is possible to cast the speculum with grooves, projections, and recesses in its back, by means of which the task of supporting it is much simplified. With a glass speculum it is not practicable to have these aids, so that the back of the speculum is cast quite flat, and usually rests on a flat plate of metal. By an ingenious method of balanced arms Mr. Common has contrived to support the speculum so that it is perfectly free from flexure. Thus the first point was secured.

The second point, or the method by which the telescope should be mounted, was a problem which required long and serious consideration. Mr. Common devised a new and most ingenious method which, after long consideration, he thought would furnish a means of steadily supporting the telescope. In this steadiness is most essential, the slightest vibration, vibrations absolutely invisible to the eye, would ruin the performance of a telescope. The weight of the moving part of the telescope amounts probably to four or five tons, and this has to be kept in motion by a clock, yet it must not be liable to the least tremor or vibration. The difficulty of the problem is evident. His plan of a mounting was submitted by Mr. Common, for criticism, to several well-known astronomers, who might be supposed competent to advise on this subject. As might have been expected, very diverse opinions were expressed; at most, one seemed to decidedly favour the plan, others seemed doubtful, and more than one were decidedly adverse. The result was to leave that matter much as it stood at first, so that Mr. Common decided to persevere in his original design. The success which has crowned his labours shows that he was correct in his judgment. It would be impossible to describe the method of mounting employed without the aid of several detailed drawings, but reference may be made to one ingenious point. As in all equatorial mountings, nearly the entire weight of the moving part of the telescope (in the present telescope five tons) rests on the bottom pivot of the polar axis. This pivot, therefore, is exposed to enormous friction, and is a common cause of vibration. To obviate this, Mr. Common, by an ingenious arrangement, supports the whole polar axis in mercury, thus taking off nearly the entire friction, and the whole instrument moves as if it were floating. By this means he is enabled to drive the whole telescope by means of an ordinary train of clockwork, regulated by the governor, which he had invented for his smaller telescope.

The last two points specified above are obtained by making the observatory itself the ladder by which you approach the eye end of the telescope, and the whole observatory revolves on iron wheels running on a circular railway. By means of a wheel on

your left, you can raise or lower yourself at pleasure, and observe with the telescope in any position. The whole observatory only requires moving about once in two hours, and can be moved with ease by one hand.

Within a year of its being begun, the telescope was rapidly approaching its completion. The great speculum had been brought to the right shape, and was partially polished, and every day the announcement was expected that it was completed, or at least only required the final finishing touches. Suddenly a telegram arrived—an ominous thing. Was it to announce an imperfect figure? This would be a most annoying thing, for it would require the whole to be reground and repolished. But no, it was very brief, but it announced a terrible misfortune. It was a pressing request to come down at once. *The whole speculum had burst into a thousand pieces.*

It was a terrible blow, for it was the very misfortune which had been prognosticated by the English manufacturers and by the greater number of astronomers, including those who had had much experience in the construction and use of specula. The explosion had been terrific. The whole workshop was covered with jagged, torn masses of glass, varying in weight from ten or twelve pounds to an impalpable dust. Mr. Calver had had a narrow escape, but he and his workmen escaped without serious injury. The monetary loss was great, and bid fair to be greater, for with the loss of the speculum the rest of the telescope became useless. It might well seem that they were right who held the view that large silver-on-glass specula were impracticable, as from the difficulty in annealing large masses of glass they might be expected to break at any moment.

Within an hour or two of receiving the telegram announcing this terrible mishap Mr. Common was in the library of the Royal Astronomical Society. While there he was met by a friend, a fellow astronomer, who, being aware that news was daily expected of the completion of the great speculum, asked him for the latest intelligence. Mr. Common calmly handed him the fateful telegram. He was thunderstruck, for it was so unexpected, and he was one of those who had looked for much gain to astronomy to accrue from the construction and subsequent employment of this grand new instrument. After expressing, no doubt imperfectly enough, his sorrow, sympathy, and disappointment, he naturally put the question—"What can you do now?" The answer came gently enough. "Do? Why, I have telegraphed over to Paris to see if I can't get two more discs of glass. It will be one to spare in case of another explosion."

Success must crown indomitable courage like this. The new discs arrived, and were duly transferred to Mr. Calver. One

was selected, and, after much labour, ground, polished, and finished. The remaining portion of the instrument and the observatory were pushed on as quickly as possible. On August 1, 1879, the instrument was complete, and the grandest and most powerful telescope in existence stood finished before its maker, designer, and owner.

An instrument of this large aperture will take a long time to thoroughly test, but it has stood triumphantly all the tests which have been applied hitherto. It has been tested on the moon, a most crucial test in experienced hands, on Jupiter and Saturn, and on faint companions to bright stars. In all cases satisfactory results have been obtained.* This proves that the telescope must be at least of fine quality, and it bids fair to turn out of the highest excellence. It has been used to take photographs of the moon, with results very satisfactory to those who are experienced in these matters. There can be no doubt, therefore, of its claims to be a success, so that ere long it will take its place in the eyes of most astronomers as the greatest optical instrument in existence, and the credit of having manufactured and of possessing the most powerful telescope in existence has now passed from America back to England.

It may be legitimately asked, What will be the future work of this grand instrument? Will it be used to increase our knowledge of astronomy, or will it be allowed to rest in idleness, like so many other fine instruments? It is to be trusted, and it may be safely anticipated, that the former will be its fate. It will wear out, not rust out. There is much in astronomy which this grand telescope can do. It can be used for observing the faint and difficultly visible satellites of Mars, Saturn, Uranus, and Neptune. All these pressingly want observing and measuring, and there are few telescopes of sufficient power and excellence to do the work wanted. It can be easily done with the new one. Then there is the important question to be settled, Are there other satellites to those planets than those known? To this telescope will fall the task of searching for a third and more distant satellite of Mars, for a fifth satellite to Jupiter, for a ninth and tenth satellite to Saturn, for a fifth and sixth satellite to Uranus, and perchance half a dozen new moons of Neptune. Moreover, there are the extremely interesting problems connected with the minor planets. Does Vesta, Juno, or Pallas, possess a satellite or satellites? If so, their discovery would be a great thing for astronomy. Astronomers suspect that away beyond Neptune there may be still another giant planet, still another member of the solar system. If so, it will

* Lately this telescope has shown the outer satellite of Mars three weeks before it was thought possible it could be seen with the great telescope at Washington.

be very faint, and it will require a powerful telescope to search for and discover it.

There is yet another field in which this new telescope may reap great advantages for astronomy. It is suspected that more than one of the stars, those distant suns, may be attended by opaque dull planets. Mathematical analysis has already pointed to the existence of these attendants. It remains for the telescope to discover them. If the new Ealing reflector be really of the very highest excellence, it will be with that instrument we ought to look for these attending planets, these members of a foreign solar system.

Lastly, there is the great field of photography. The new telescope takes instantaneous photographs of the moon two and a-half inches in diameter, photographs which can be enlarged with ease to good pictures of the moon a foot in diameter, pictures which will be valuable for astronomy, not mere interesting curiosities of science. It will, moreover, take photographs of Venus, Jupiter, Mars, and Saturn, showing much detail, and capable of being enlarged to half an inch in diameter. These planetary photographs will be of great use, as recording in unmistakable characters the true position and aspect of these planets and their satellites at different known epochs.

The foregoing sketch will show that in constructing this new instrument Mr. Common has contributed in a most important degree to the advancement of astronomy.

FLIGHT AND ITS IMITATION.

By FRED. W. BREAREY, Hon. Sec. Aëronautical Society of Great Britain.

THE persistence with which men in all ages, as far as history travels, have pursued the study of flight, proves that there is a better foundation than the mere wish to fly in favour of their aspirations. The hope has outlived the empirical attempts of our progenitors. The same examples of flight are presented to us as to them. We have equally looked upon accomplished facts, viz., the transportation of heavy bodies in a medium so thin that we breathe it.

Some time previously to the Montgolfier discovery, M. Blanchard had made several unsuccessful attempts at flight by means of wings. He hailed with renewed hope the invention of the balloon, by the aid of which he thought that he could attain the buoyancy denied to him by the manipulation of wings alone; not only, however, is buoyancy destructive to mechanical flight, but the magnitude of the means employed to obtain it dwarfed all his apparatus. The effort at flight was imperceptible; and at length he used his wings in beating the air so as to retard descent, which in some cases he no doubt achieved. The balloon remains as an aid to man, not yet sufficiently utilized, although in the sense of aërial navigation its scope is too limited ever to be of commercial utility. The bird in the air, however, still continues to present itself a living witness and fulfilment of a great mechanical problem up to the present time unadapted to man's aërial transit. All the great inventions by which the world has benefited have been worked out in the study, and often in the ill-supplied workshop of the man of science, sometimes for ages before the money-maker deemed them worthy of his attention. And so, during these latter years, the subject of aërial navigation has been approached with the certain knowledge that if its solution lies in the adoption of mechanical means, in compliance with mechanical laws, then the problem must of necessity be solved by the increased, and increasing, knowledge and intellect of man. What, then, is the foundation for the hope that man

will ever be able to navigate the air? First, of course, the fact that creatures possessing weight are endowed not only with perfect adaptation of means, but with the mechanical instinct to put them to use without waste. The students of aëronautics say that they can imitate such means. It is clear, however, that to construct the required apparatus, without the attainment of precise knowledge as to the work which the apparatus is to perform, would be useless labour. Societies have been formed to discuss the mechanical conditions. The Aëronautical Society of Great Britain, of which I have the honour to be honorary secretary, was formed immediately after the subject was introduced by me in a paper read before the British Association at Birmingham in 1865. The papers and discussions, printed in our annual reports, have thrown much light upon the action of a bird's vibrating wing upon the air.

We all know what this thin medium can effect when in motion as what we call wind. Our critics, courteously sometimes, strive to conceal their amusement when we talk to them of one day navigating the air. To them the balloon, being a fact accomplished, presents the only means because of its buoyancy To them the tornado presents no suggestion.

Ships, trees, houses, and towns may be scattered like sand, but to them no idea is presented. I lately read a report of a hurricane in New South Wales in which the speed and force of the air were carefully taken. For a short time the velocity of the wind was stated to be 153 miles per hour, and the pressure no less than 117 lbs. upon a square foot of surface exposed to it.

When speaking to men of science upon the subject of the navigation of the air one often hears the expression: "Yes; I don't doubt that some day or other the question will be solved, but not in our day." This is meant to be an easy and safe way of avoiding the discussion of the subject. The savant smiles, and says, "Good day to you;" and leaves his interlocutor in wonderment that even with his hands well sanded his eel has escaped him. "Not in our day," he repeats, and ponders in wonder as to the true application of the expression by so very learned a man. "Not in our day;" and why not in our day? Has there ever been in the world's history a time so marked by various discoveries and inventions as the present day?

The wonderful grasp which man has obtained of force, of the origin of which he is ignorant and of which he yet makes excellent use for many purposes which were utterly inconceivable a few months or years since, absolutely throws into insignificance the hopes of those who desire, by mechanical means alone, to apply to the air the same conditions imparted to it by the mechanical wing-action of the bird, by which it sustains in motion a weight out of all proportion, in human conception,

to the surface of its wing; yet in exact proportion to the requirements of sustentation and progression in the atmosphere. The mechanical conditions of flight must, therefore, be thoroughly understood before they are attainable.

To imitate Nature is a natural and laudable aspiration, and it would appear more hopeful to strive after success in obedience to a precedent, than to attempt to put in harness an unknown power for the accomplishment of objects for which in Nature there is no visible or tangible precedent whatever.

I venture to say that if certain recent discoveries had been published for centuries previously, as objects to be attained by constant study and application, the uninstructed portion of mankind would have held in derision the notion of a future for the electric telegraph, the phonograph, the phonoscope, and the telephone.

Resistance is no less caused by a surface in motion against the air than by the air in motion against the surface. With this great advantage in favour of the surface moving against the air, that the speed and pressure can be regulated to the point of efficiency and safety. It is this resistance which the bird creates for itself in the calm of a sultry summer's day by the agitation of its wing-surface; in obedience to which certain mechanical actions are evoked, tending to impel it through the still air. The resistance to the down-stroke of the wing and the resistance to the up-stroke are resolved into a sustaining and propelling power. It is conceded that any mechanical contrivance which will cause the resistance encountered by the up- and down-stroke to be resolved into a single force, must in air have the effect of flight, other matters being in accordance.

But, apart from theory, let us see what is the precise action of the air when agitated by the up- and down-stroke of a wing. We need not theorize here—we can submit the matter to ocular demonstration, and the effect is conclusive as well as surprising. Not to my knowledge has any similar explanation been afforded.

Take the natural wing of a bird—in my experiments I used the wing of the carrion crow, in length twenty inches—approach a gas flame, and wave the wing, presenting to the flame the anterior edge, commencing at the base, and drawing it towards you until the tip is reached. It will be observed that the flame is sucked in underneath the wing in both the up- and down-stroke throughout its whole length. Now present to the flame the posterior edge; the same action is observable in both the up- and down-stroke, until near the tip, where the flame will alter its behaviour and be forcibly expelled, the strong current effecting sometimes its extinction.

Here we have the bulk of the wing-surface rendered effective in support, in both the upward and downward action, whilst towards the tip of the wing resides the propelling action.

The great difficulty which the inventor has met with in his desire to encounter the atmosphere in the manner of a bird has faced him at the very first step; it is, we may say, the goose step, the first step in flight—flight itself by simple wing action. We have, however, latterly attained to this, and have thereby assured ourselves that those natural flying machines—the birds—are not supported and propelled by some occult agency unrecognized in any school of science.

That no highly rarefied air in or about the body of the bird is essential to flight.

That no arrangement of feathers so that in the upward stroke the air shall pass through them, whilst in the reverse stroke they shall be impervious to its passage, is necessary to accomplish an imitation of flight. I have shown many examples. When, however, we come to the transport of weight by such artificial means—such weight, for instance, as is presented by the living prototypes whose shape and proportion of wing we attempt to imitate, such as the rook, the blackbird, swallow, or albatross, with twelve feet stretch of wing—we become perplexed, or, rather, we have hitherto been perplexed, because it is the object of this paper to show that this difficulty is receding before the more perfect knowledge which is always attainable by those bulldogs of science who are determined to retain their grip of an object of which they have once realized the flavour.

Experiments with the wings of the dead bird have hitherto been unsatisfactory.

I have myself not been successful in attaining flight by the attachment to my apparatus of any birds' natural wings. I attribute this to the absence of that elasticity which pertains to the living prototype. The best examples of flight by models, which I have yet attained, are in those instances where the wings have been made more than usually flexible. This is an encouraging feature, because the manufacture of a rigid wing of the dimensions necessary to support a man would necessitate great weight; in fact, it would be impossible to control its action by any motive power without great danger of fracture. I have seen such a wing fractured at the first stroke.

The apparently insuperable difficulties attending the accomplishment of manual flight by wing action have stimulated efforts in the direction of plane surfaces propelled by screws.

The late Sir George Cayley, a Yorkshire baronet, well known for his persistent experiments for the attainment of locomotion in the air, states, with respect to plane surfaces, "About sixty years ago, many experiments on a large scale were made by this means, some of the aërial vehicles having three or four hundred feet of canvas extended on masts, and braced by rigging, and

a surface of fifty-four square feet, weighing 11lbs., was found to support 126lbs. in its waft. These trials proved in a most decided manner that perfect stability and guidance were attainable.

"For instance, it was proved that a man placing himself on a machine of proper dimensions for his weight, at the top of a mountain, say one mile above the level of the plain below, might in calm weather, with steadiness and security, proceed through the air to any place he might choose to steer, about eight miles in a horizontal direction. Of course the line of flight would be in a continuous descent of 1 in 8; gravity being the only cause of the motion of the machine."

So that the propulsion of such a surface is not a preposterous idea. Mountain tops, however, are ideal in the majority of localities, so that, in order to find a substitute for that rarity, it was gravely proposed by a gentleman who called himself a civil engineer, that the line of flight being first determined upon, high towers should be erected at suitable distances, from the top of which a machine of considerable dimensions, with passengers, might be started, and so steered to the foot of another high tower, to the top of which the machine could be hauled, while the passengers walked up the stairs, and were launched to the foot of the next high tower!

To avoid high towers and mountains must of necessity become the aim of the plane-propeller, and there is just this difficulty, Can he by any auxiliary power leave the ground by rising in the line of least resistance?

Well, this has never yet been accomplished. No speed that has yet been attained on the level road, or even down an incline, has hitherto proved sufficient to enable a surface advanced at any angle against the air to leave the ground and complete its flight in the air. Of course there is a velocity relative to weight and surface which will affect this achievement, and as an experiment it will no doubt be effected, but when done it will only class with balloon propulsion. It has been shown that, as a fact, the balloon can be propelled, and when the attainment of a speed of six or eight miles an hour in a moving body of air of varied velocity, whose direction may or may not be in favour of the desired course, will conduce to the object sought, then the knowledge may prove useful, and the expenses connected therewith may count for nothing in view of its importance.

That which I have advanced respecting the plane relates only to the stiffened plane surface propelled at a fixed inclination against the air. The conditions would, I believe, be quite altered if the plane surface could be made to assist itself during its preliminary run; and I think that I am justified in my

opinion by reference to some long-winged birds that effect their rise from the ground, not alone by extending the wings as planes, but by using the air as a fulcrum which is increased in solidity by the multiplication of the vibratory wing-action.

Mr. F. H. Wenham, in the first paper read before the Aëronautical Society, speaks of the eagle which he sees sitting in solitary state in the midst of an Egyptian plain.

"An approach to within eighty yards arouses the king of birds from his apathy. He partly opens his enormous wings, but stirs not yet from his station. On gaining a few feet more, he begins to *walk* away. Now for the chance fire. A charge of No. 3 from 11 bore rattles audibly but ineffectually upon his densely feathered body. His walk increases to a run, he gathers speed with his slowly waving wings, and eventually leaves the ground. Rising at a gradual inclination, he mounts aloft, and sails majestically away to his place of refuge in the Lybian range, distant at least five miles from where he rose. Some fragments of feathers denote the spot where the shot had struck him. The marks of his claws are traceable in the sandy soil, as at first with firm and decided digs he forced his way, but as he lightened his body and increased his speed *with the aid of his wings*, the imprints of his talons gradually merged into long scratches. The measured distance from the point where these vanished to the place where he had stood, proved that, with all the stimulus that the shot must have given to his exertions, he had been compelled to run full twenty yards before he could raise himself from the earth."

Thus Nature teaches us; but there is such an infinite variety in the mode of flight, and in the manner of progression, both in water and in air, that though we may never get the proverbial pig to fly, we may possibly be able widely to depart from any known form.

The difficulties which inventors have foreseen, and sometimes encountered without foresight, are—the construction of wings which shall be of the great lateral extension considered to be necessary;—strength of structure;—ability to manipulate them. The preservation of a certain amount of rigidity throughout the whole length, decreasing towards the tips, and especially so between the anterior and posterior portions of the wings' edges—the great strain upon the posterior edge, which cannot be framed to any attachment without destroying the whole principle of action—and the small amount of sustaining surface by reason of the comparative narrowness of wing, under which it is impossible to see safety unless by the preservation of an acrobatic balance.

All these considerations have militated against the employment of wings for progression and support upon the air.

It is evident that if the wing surface could be extended longitudinally and there attached, something like the small end of a kite, to the extremity of its backbone, thirty feet behind, the surface thus exposed might be made ample enough to sustain man and motive power. In fact, it would be easy so to extend 300 or 400 feet of canvas by wing arms, twenty feet long from tip to tip; but *the surface would not be in tension.*

It may have been observed that the best flying kites are those which "belly" with the wind, or in other words, form a concave towards the wind. Would such an arrangement prove effective? If so, then I can see safety under such an extent of surface. I can also see that this surface would take a concave form in its descent, and so prove to be a longitudinal parachute which would bring a weight down in perfect safety.

Is there any example in Nature which would warrant the supposition that such an arrangement would be effective? Well, if we go to an aquarium, and watch the mode of progression of some fishes, we shall find that some of the flat-fish—notably the skate—progress by a wave-like action of the whole of their bodies. We cannot, of course, impart a wave action to the framework which shall extend our canvas, but we can do so to the canvas, and the question arises, Will a surface so vibrated support as well as propel? I can aver that a model made upon this principle, which I discovered for myself, behaved in a perfectly satisfactory manner. The wave action is imparted to it by the vibration of two wing arms, which cause a succession of waves to flow from the front to the extreme end; and I find that it will not be difficult to manufacture those arms twenty-four feet from tip to tip, light, elastic, and incapable of fracture, consisting, as they will, of bundles of canes wrapped together firmly, from base to tip, with whipcord, and tapering the whole by cutting off a cane every foot or so. My idea is, that if the whole were placed upon wheels, and a wave action imparted to the fabric by steam or compressed air, it would perform much the same feat as Mr. Wenham's eagle. The parachute action upon cessation of motion leaves nothing to be desired, amenable as it is to proper management in the disposal of the ballast.

The sustentation of a weight in flight by wing action depends entirely upon power, strength of material, and surface. As power and strength are increased, the surface may be curtailed. I scarcely, however, dare to hope for any such result as spoken of by Sir George Cayley, for in that case I might expect that 400 square feet of canvas would support more than 800 pounds.

The surface, however, being its own propeller, satisfactory results may be expected. I have a model, for instance, of the dimensions of an albatross. Now if it is supposed that a fabric

is attached to the wings, from tip to tip, and from thence taken to the tail, we should then have a comparatively loose surface, having no intermediate support but that afforded by the central shaft. Upon the waving of the wing arms we should then get a wave action longitudinally as well as laterally.

This double action proving effective we might then have above us a cloud of canvas, supporting and propelling, and presenting an extent of surface that would look more like safety than anything which has hitherto come under my notice. To these advantages may be added the statement that for aërial transit it would be only necessary to clear obstructions, and that those highly-coloured pictures of so-called "aërial machines," "up above the world so high," do not represent faithfully our aspirations.

I have now given the reasons for the ambitious hopes that some of us entertain, and I conclude with the expression of a desire that more minds may be directed to the attainment of our objects.

REVIEWS.

FRANKLAND'S EXPERIMENTAL RESEARCHES.*

IT is not often that a man, who has only just passed the meridian of life, can point to so huge a mass of original work as is represented by the noble volume which Dr. Frankland has placed in our hands. For upwards of thirty years this distinguished chemist has successfully devoted himself to the prosecution of experimental inquiries, and has naturally contributed, during this period, a large number of memoirs to the transactions of our learned bodies, especially to the Royal and the Chemical Societies. Looking back upon the accumulated labours of his life, he has deemed it well to gather up these scattered fragments, and to piece them together in connected form. But it must be remembered that the author has done much more than simply collect and co-ordinate his memoirs. To each chapter of his work he has prefixed an introduction, indicating its scope, and pointing out the connection of the several papers one with another. Those who are interested in chemical science—whether, in its pure, its applied, or its physical aspect—will assuredly be grateful to the author for presenting his work in so complete and compact a form.

How great a revolution has swept over chemistry since the earliest of Dr. Frankland's papers were published! A young chemist, fresh to-day from the laboratory and the lecture-room, and who has read only modern text-books, could scarcely understand a memoir written thirty years ago; and, on the contrary, if a chemist of that period had fallen asleep, and could be aroused to-day, he would find our modern memoirs equally unintelligible. The current of chemical thought has, in fact, been flowing in new channels; the notation formerly in vogue has been completely altered; the very language of the laboratory has changed. Above all, the idea of atomicity or quantivalence, an idea which lies at the root of modern chemistry, had not been conceived thirty years ago; and the reproduction of these memoirs reminds one of the part which Dr. Frankland has played in introducing this conception to the scientific world. Fully admitting what has been done by such men as Kekulé and Cannizzaro, it must be conceded that the germ of the modern doctrine, the root of the new theory, was due to Frankland's remarkable studies of the organometallic bodies.

* "Experimental Researches in Pure, Applied, and Physical Chemistry." By E. Frankland, Ph. D., D.C.L., F.R.S., &c. 8vo. London: Van Voorst, 1877.

In order to secure uniformity in the work which is now before us, Dr. Frankland has so modified some of his early papers as to bring them into accordance with modern ideas. In transcribing these memoirs he has naturally followed his peculiar system of notation. This we of course expected to find; but, nevertheless, we cannot help regretting the step. In fact, ingenious as Frankland's system unquestionably is, it may be fairly doubted whether it is destined to survive its author; and it is certain that it never would have attained to its present position, had it not been for the very influential position which he occupies, and the power which he thus has of leading most of the younger chemists. As a matter of course, the pages of the massive volume in our hands are freely besprinkled with those obtrusively thick symbols which stand as initials to indicate the elements of highest atomicity in the formulæ, and with those confusing little o's, which enter so commonly into the formulæ of the metallic radicals, and are the pest of a printer.

Dr. Frankland's researches naturally arrange themselves in the form of a triad, dealing as they do with Pure, with Applied, and with Physical Chemistry. In the department of pure chemistry, we find those famous organic researches, partly analytic and partly synthetic, on which Frankland's fame was originally built, and will always rest. In the applied section we have not only his well-known studies on gas illumination, but also those investigations on the pollution and purification of water, by which Dr. Frankland's name is everywhere known. Finally, in the physical group of papers we meet with a reproduction of his researches on flame—those researches which have sometimes been cited to disprove the long-established results of Davy.

On closing this work, which runs to upwards of a thousand pages, we must admit that it is anything but light reading. The volume belongs, in fact, to the class of books which Dr. Johnson described as being "more easy to praise than to read." Still, so many of Dr. Frankland's researches have become classical, that the work in which they are reproduced should at once take a place in every chemical laboratory and library.

GEOLOGY OF IRELAND.*

THIS little work is well printed, prettily illustrated, and altogether tastefully got up; but having said this, we are unable to add much else in its favour. The object of the writer has been to present the outlines of geological science in simple fashion, and with special reference to the rocks which occur in Ireland. It is to be regretted, however, that before undertaking this task, he did not prepare himself by a deeper study of his subject. Whether in its geology, its palæontology, its mineralogy, or its chemistry, there is much in the book to which we are bound to take exception. What, for instance, can be more absurd than the statement that basalt "consists

* "Outlines of Geology, and Geological Notes on Ireland." By William Hughes. Third edition: revised, considerably enlarged, and with numerous Illustrations. Sm. 8vo. Dublin: M. H. Gill & Son, 1870.

principally of silica, oxide of iron, felspar, pyroxene, alumina, and lime?" It is scarcely conceivable that a writer on geology should have so little knowledge of the composition of a common rock, like basalt, as to mix up the mineralogical and chemical constituents in this ridiculous way. But while we are unable to recommend the work as a safe guide to the student, we admit that some parts are pleasantly written, and may be read with interest by anyone who requires only a superficial view of geology. It should be noted that the work is provided, as we are told in large letters on the title-page, with "an addenda!"

BEE-KEEPING.*

ALTHOUGH we cannot pretend to an acquaintance with all the published manuals of Bee-culture, whose name is legion, our acquaintance with apiarian literature is sufficient to enable us to form a pretty good judgment of the merits of Mr. John Hunter's little "Manual," a third greatly improved edition of which has just been published. Mr. Hunter gives a brief sketch of the natural history of the Hive Bee, in which, without going very profoundly into the matter, he furnishes his intended readers, the practical apiarians, with just that amount of information which will enable them to understand the management of their hives and take an intelligent interest in the doings of the little inhabitants. He especially expounds in a very clear and easily intelligible fashion the modern theory of the reproduction of Bees, founded by Berlepsch and Siebold upon their own researches and those of Dzierzon.

Bee-keeping has made rapid advances during the last few years both in Europe and America, and the inventive genius of our cousins on the other side of the Atlantic has been greatly exercised in the construction of numerous ingenious appliances for the better management of the Bees, including the observation of their doings, and for facilitating the winning of a harvest of pure honey without having recourse to the old barbarous process of destroying the industrious insects which produced it. Of the success of these devices we have abundant proof in the quantities of honey and clean honeycomb which have been of late years imported from the United States; and one of Mr. Hunter's objects in preparing his little book is to transfer some portion at any rate of the profits of the honey market to the pockets of his own countrymen. With this view he describes very clearly the best methods of managing Bees, and devotes very considerable space to the consideration of various forms of hives, in which we are glad to see that he regards simplicity of arrangement as one of the most desirable characteristics, considering that many of the supposed improvements which have been lately introduced, are chiefly adapted "to increase expense, and confuse the unfortunate tyro in Bee-keeping." In other chapters the actual management of the insects with the view of securing the greatest amount of profit from their labours is very fully and lucidly explained; and of all the "Bee-books" that we have seen,

* "A Manual of Bee-Keeping." By John Hunter. Third edition. Sm. 8vo. London: D. Bogue. 1879.

this seems, from its straightforwardness, and from the care with which the author has made use of recent contributions to apiarian literature, to be the best adapted to enable anyone of moderate intelligence to carry on Bee-cultivation with success. Besides its technical use, however, the little volume will prove of considerable interest, even to the general reader, who will be rather surprised at the ingenuity of some of the devices employed for the profitable government of the hive, which used to be regarded as a model republic. Andrew Fairservice, it will be remembered, described Bees as a "contumacious generation," because "they hae sax days in the week to hive on, and yet it's a common observe that they will aye swarm on the Sabbath-day, and keep folk at hame frae hearing the Word." Had he lived in the present day, he would have learned that it was possible to make them swarm when he thought it most desirable. But the most remarkable interference with the internal economy of the hive is the actual regulation of the constitution of its population, by the introduction of "foundation combs" fixing the size of the cells to be constructed, and consequently, in a hive with a healthy queen, the nature of the progeny to be reared.

The little book is well and copiously illustrated.

GANOT'S PHYSICS.*

WHEN a work has attained to the position as an educational text-book that is enjoyed by Dr. Atkinson's English edition of Ganot's "Elements of Physics," the reviewer's work, as each successive issue makes its appearance, is reduced to a minimum. For all practical purposes, a mere statement of the fact is sufficient, and we have much pleasure in announcing the publication of a ninth edition of the above-mentioned admirable handbook. In this, as in each previous issue, the bulk of the book has somewhat increased, so that it now constitutes a very stout volume, tending in fact to become portly with advancing years. In the present edition we find, besides a great number of minor alterations and additions scattered throughout various chapters of the book, very clear and explanatory descriptions of those curious inventions which have made so much noise in the world during the last few years, such as the telephone, microphone, tasimeter, and phonograph; the electric light also comes in for its share of attention; and these popular subjects seem to occupy about half the twenty-five pages which, as Dr. Atkinson tells us, have been added to the bulk of the volume.

GRAY'S BOTANICAL TEXT-BOOK.†

AFTER the lapse of two and twenty years, the veteran American botanist, Professor Asa Gray, has commenced the publication of a new (sixth)

* "Elementary Treatise on Physics: Experimental and Applied." Translated and Edited from Ganot's "Éléments de Physique," by E. Atkinson, Ph.D., F.C.S. Ninth Edition, Revised and Enlarged. 8vo. London: Longmans. 1879.

† "The Botanical Text-book." Sixth edition. Part I.:—Structural Botany or Organography on the Basis of Morphology, &c. By Asa Gray, LL.D. 8vo. New York and Chicago: Ivison, Blackman, Taylor & Co.; London: Trübner. 1879.

edition of his well-known "Botanical Text-book." The foundation of this elaborate work is to be found in a small book published under the title of "Elements of Botany" more than forty years ago, which was followed in 1842, the year in which the author entered upon his professorial duties in Harvard University, by the first edition of the "Botanical Text-book." In this, as in the present issue, the author founds all his work on a morphological basis, a mode of treatment which was novel when first adopted by him, but which most recent writers on the principles of botany have adopted.

By the development of the subject, and perhaps of the ideas of the author, the plan of this sixth edition has been much enlarged. Instead of a single volume it is to consist of four, the first of which only is now before us, devoted exclusively to structural botany and the principles of systematic botany, with reference, however, solely to phænogamous plants. The treatment of the subject is the same as in former editions, proceeding from the organography of the seedling plant to trace the structure, form, and arrangement of all the parts to be developed from it, but in the details we find much that is new, as might indeed be expected from the advances that have been made in botany, as well as in other departments of Natural History, in the last twenty years. Thus, to take a single example, we find an entirely new section introduced, dealing with the various adaptations of flowers for intercrossing and close-fertilization, in accordance with the views so convincingly put forward by Mr. Darwin in various works, and supported by an immense body of observations recorded by other naturalists, now constituting, as our author says, "a copious special literature."

In the chapter devoted to Taxonomy, or the Principles of Botanical Classification, the author expounds his views upon the origin of species. He accepts the doctrine of evolution in the following sense: Variation, "if sometimes called out by the external conditions, is by way of internal response to them. . . . Each plant," he holds (with Nägeli), "has an internal tendency or predisposition to vary in some directions rather than others; from which, under natural selection, the actual differentiations and adaptations have proceeded. Under this assumption, and taken as a working hypothesis, the doctrine of the derivation of species serves well for the coordination of all the facts in botany, and affords a probable and reasonable answer to a long series of questions which without it are totally unanswerable. It is supported by vegetable palæontology, which assures us that the plants of the later geological periods are the ancestors of the actual flora of the world. In accordance with it we may explain, in a good degree, the present distribution of species and other groups over the world."

The tenth and last chapter in the book deals with Phytography, or the nomenclature and method of describing plants, and includes also a few remarks on the formation and management of the herbarium, and a list of the usual abbreviations of the names of botanical writers. A copious glossarial index concludes the volume, which is beautifully printed and copiously and well illustrated. As the author says in his preface, "It should thoroughly equip a botanist for the scientific prosecution of systematic botany, and furnish needful preparation to those who proceed to the study of Vegetable Physiology and Anatomy, and to the wide and varied department of Cryptogamic Botany." These two branches of the science constitute the subjects

to be treated of in the next two volumes, the preparation of which has been handed over by the author to his colleagues, Professor Goodall and Professor Farlow. The fourth volume, giving a sketch of the natural orders of phænogamous plants, with other special information, Professor Gray says that he rather hopes than expects himself to prepare. We sincerely trust that this hope may be fulfilled.

THE CAPERCAILLIE.*

IT is so long since the present writer had the pleasure of seeing a certain book which once upon a time made a considerable noise in the world, namely, MacPherson's version of the Poems of Ossian, that he cannot say whether the Great Cock of the Woods figures therein, although his impression is that it does not. Nevertheless, there can be no doubt that this bird ought to have made his appearance somewhere in the poetical record of the doings of the Fingalic chiefs. In the days of Fingal he must have been abundant in many parts of Scotland, and as he inhabits, not the inaccessible summits of the mountains, but the wooded region near their foot, and, being nearly as big as a turkey, furnishes no contemptible supply of savoury food, we can hardly suppose that his body was absent from the feasts with which the warriors of those days prepared themselves for those copious libations of whisky (varied occasionally, no doubt, by a little dirk practice), in which they celebrated their feats of arms.

Even in later days the records of the occurrence of this grandest of all European game birds in Scotland are of the scantiest description, and the earliest of them, an often-quoted passage from the description of Scotland by Hector Boetius, dates only from 1526. From this time down to 1760, about which date the species appears to have become extinct, we have only a few scattered references to the existence of the bird in Scotland. Of its presence in Ireland, the evidence, although sufficient, is still more scanty. The earliest references are those of Giraldus Cambrensis, and Higden, the monk of Chester (1357–1387), both of whom mention "pavones silvestres," which in all probability were Capercaillies. In Ireland also the species appears to have become extinct about 1760; although, according to one authority, the birds still existed in that country as late as 1787.

All the references to the former existence of the Capercaillie in the British Islands have been carefully brought together by Mr. Harvie-Brown, in his book, entitled, "The Capercaillie in Scotland;" in which he also discusses the origin of the names given to the bird, of which the most correct would seem to be *Capullcoille*, signifying "Horse of the Wood." By Boetius it is spoken of as the "Auercalze," which is interpreted in like manner, and this name is of interest from its connection with the German "*Auerhahn*" (Bison-cock), represented by the Latin word *Urogallus*, which was adopted by Linnæus as the specific name of this great grouse. Upon these and other critical points the reader will find abundant information in Mr. Brown's work.

* "The Capercaillie in Scotland." By J. A. Harvie-Brown, F.Z.S. 8vo. Edinburgh: Douglas. 1879.

With regard to the extinction of the Capercaillie in the British Islands about a century ago, the author is of opinion that this was due mainly to "the destruction of great forest tracts by fire, the cutting down of the same by man. . . . . and the wasting away of the forests from natural causes, by the conversion of dry forests into bogs and morasses, and, resulting from this, the decrease of, and changes in, the food of the species," which, as is well known, consists for the greater part of the young shoots of firs and larches. The increase of population, no doubt also, as suggested by Mr. Colquhoun. may have had some share in bringing about the extermination of the Wood Grouse; but it is mainly to the destruction of the forests, with no adequate replacement by the systematic planting of new woods, that the author is inclined to ascribe the disappearance of the species. Some Irish writers of the last century who witnessed the extinction of the bird in Ireland, express the same opinion.

The most interesting and important part of Mr. Brown's book relates to the re-establishment in the British Islands of the great Wood Grouse, and is the result of a series of minute inquiries instituted by him with the object of obtaining precise information to be used by Professor Newton in his edition of "Yarrell's British Birds" now in progress. From this we learn that, after several unsuccessful attempts, a considerable number of the birds imported from Sweden were introduced on the property of Lord Breadalbane at Taymouth in the autumn of 1837 and the spring of 1838, and that the progeny of these and subsequent colonists have not only established themselves on a firm footing at the original locality, but have also, as detailed in the text, and shown very clearly on a small map accompanying this section of the book, spread in various directions over a considerable portion of east central Scotland. For the most part this redistribution has been effected by the birds themselves, and the means of watching in a convenient fashion the perfectly natural extension of a species over a large extent of country is thus afforded to the naturalist. The course of events seems to be somewhat as follows:—When the Capercaillie population of a given locality becomes too large for its resources in the way of food, some individuals (generally, if not always, females) start off in search of a new abode, at first naturally following the line of the valley in which they find themselves, but also not unfrequently taking a freer flight, sometimes to very considerable distances. The females usually precede the males by one or two years, and owing probably to this circumstance, hybrids between the Black Cock and the Capercaillie are not unfrequent in localities inhabited by the former. The establishment of the species generally takes place very soon after the arrival of the males.

On the mainland of Scotland unsuccessful attempts to establish the Capercaillie have been made in several of the southern and western counties, and notably in Ayrshire; but in the island of Arran they have been introduced by means of birds obtained from Taymouth and Sweden in 1843 and 1846.

The re-establishment in Britain of this fine game bird appears not to be regarded with unmixed satisfaction by all parties. At least two grievous charges are made against him—namely, that he causes considerable damage to young trees by feeding on their growing shoots, and that he drives away or otherwise causes a diminution in the number of the Black Grouse. Of

the first of these charges Mr. Brown does not, we think, wholly acquit the Capercaillie, although he argues strongly for its extenuation, urging especially that much of the actual damage is probably done by squirrels and other destroyers; whilst he inclines to think that a great deal of apparent damage is due to the fact that many nurserymen seem to supply planters with an inferior race of seedlings, which could never under any circumstances make good trees. Of the second crime charged against the Wood Grouse, on the other hand, our author thinks he is not guilty; and accounts for the undoubted decrease of the black game, which takes place in localities where no Capercaillie has yet shown his beak, by changes in the condition of the ground brought about by drainage and other improvements. We cannot follow Mr. Brown further into this interesting question, but will conclude by recommending all earnest ornithologists to buy his book and read it for themselves.

RECORDS OF SCIENCE.*

WE are glad to see that Mr. Spencer F. Baird continues, with the assistance—as he justly says—of eminent men of science, the publication of his excellent "Annual Record of Science and Industry." The volume for 1878 contains a useful summary of the progress of science during the year, carefully classified under the various departments, and each section bearing at its head the name of a *savant* by whom, or under whose superintendence it has been prepared. As a matter of course, it cannot be expected that every published scientific paper or work can be referred to in a summary extending only to about 620 small octavo pages; but, so far as the writer can judge from an inspection of those parts with which he is most familiar, the selection of articles to be noticed has been very judiciously made, and few important contributions to scientific literature are passed *sub silentio*. The summaries themselves are also very well executed. We would suggest, however, that the utility of the work would be greatly increased, if references were in all cases given to the sources of the various articles. The volume concludes with a Necrology and a Bibliography of "select" works in science.

BRITISH PLANTS.†

THE work of a catalogue-maker is generally regarded with but little favour, but there are few things for which the student of natural objects has more occasion to feel grateful, than the production of a judiciously prepared list of the subjects of his study. The writer of a manual, no doubt, performs a higher service to his fellow-workers, and his labours may often be wearisome enough, but he is at least sustained under their pressure, by a certain feeling

* Annual Record of Science and Industry, for 1878. Edited by Spencer F. Baird. 8vo. New York: Harper. London: Trübner, 1879.

† The Student's Catalogue of British Plants, arranged according to the Student's Flora of the British Isles, by Sir J. D. Hooker. Compiled by the Rev. George Henslow. 8vo. London: Bateman, Portland Town, 1879.

of doing something original, with which the compiler of a mere catalogue cannot console himself. The Rev. George Henslow has just put in this last claim to the gratitude of English botanists, by the publication of a "Student's Catalogue of British Plants," founded upon Sir Joseph Hooker's "Student's Flora," and indicating all the species and sub-species, and the chief recognised varieties of the "British Phanerogams" and "Vascular Cryptogams." The pamphlet has been privately printed, but Mr. Henslow has placed copies in the hands of a bookseller who will send them to purchasers by post.

CANADIAN PALÆONTOLOGY.*

FROM the "Geological Survey of Canada," we have received the first two parts of a work on the Mesozoic Fossils of certain outlying parts of the great region to which its investigations are devoted. In the first of these, published three years ago, Mr. J. F. Whiteaves describes and figures a series of fossil Invertebrata, chiefly Mollusca, collected by Mr. James Richardson, from the coal-bearing rocks of the Queen Charlotte Islands; in the second, the same palæontologist deals with the fossils of the Cretaceous rocks of Vancouver, and adjacent islands in the Strait of Georgia; these deposits also containing beds of coal.

In the case of the rocks of the Queen Charlotte Islands, the examination of these fossils is of particular interest, as they seem to show clearly that, so far as can be judged by their Fauna, these deposits occupy the same intermediate position between the Oolitic and Cretaceous series, as interpreted by European types, which seems to belong to several groups of rocks in other parts of North America. The general character of the Fauna appears to be like that of the Shasta group of California and British Columbia, of which the author thinks it will be advisable to regard them as representing one of the oldest members; at least, until further information on the deposits grouped together under the above name shall be obtained.

The fossils from the Vancouver district, on the other hand, are of unmistakable Cretaceous age, and are considered by Mr. Whiteaves to indicate that the deposits from which they are derived are the equivalents of the European Upper Cretaceous series; at least, so far as the four lower divisions which he distinguishes among them are concerned: with regard to three upper divisions, it is uncertain, at present, whether they are Cretaceous or Tertiary.

These publications on special departments of North American Palæontology will be of great interest in the discussion of the equivalence of the North American and European Cretaceous deposits, and in the solution of the great question of the sequence in time of the formations in various parts of the world, if that problem is destined ever to be solved. The total number of species noticed or described are 45 in the first, and 94 in the second part, and 17 species in each series are regarded as previously undescribed. These and the greater part of the known species are very well figured upon 20 plates.

* Mesozoic Fossils, Vol. I. Parts 1 & 2. By J. F. Whiteaves, F.G.S. 8vo. Montreal: Dawson Bros., 1876 & 1879.

BURNHAM BEECHES.*

ANOTHER volume from the pen of Mr. Heath, the writer of several books on trees and ferns, which have been at different times noticed in our pages, has lately reached us, of which at least it may be said that "it is only a very little one," although we fear it can hardly hope for a much longer ife than the unfortunate infant for whose appearance in the world the same excuse was made. It is indeed far from being one of the author's happiest efforts, and though we are assured that it has been written *con amore*, it seems to lack the freshness of his earlier works. Mr. Heath had, however, some claim to be heard on the subject, as it was through his representations to the Corporation of the City of London, that "the Beeches" were preserved from the inroads of suburban villa builders, and have now become for all time the property of the inhabitants of London. In the "Keepsake" of 1829, Henry Luttrell wrote of Burnham Beeches—

"O ne'er may woodman's axe resound,
Nor tempest making breaches,
In the sweet shade that cools the ground
Beneath our Burnham Beeches!"

to which Mr. Heath appends a note:—"O prophetic soul! a nineteenth-century population has re-echoed your wish, and a nineteenth-century Corporation of London has struck the woodman's axe from the woodman's hands. May the 'tempest' be equally merciful!" This is all very well, but we would venture to suggest that this verse contains no prophecy; and it is sincerely to be trusted not only that this charming spot will be spared by the tempest, but that it will also escape that utter desecration at the hands of a rabble of holiday-makers to which unfortunately some other recreation grounds for London are regularly subjected. Half the charm of rural and especially of sylvan scenery arises from the sense of comparative quietude and seclusion; and if swings, roundabouts, and donkey drivers once gain a footing in the Burnham Paradise, most of us will be inclined to echo the closing words of the "poet" just quoted, and say

"Farewell to Burnham Beeches!"

Mr. Heath's little volume is very prettily illustrated, chiefly with woodcuts from his namesake's beautiful photographic views. He also gives an outline map of the locality.

* "Burnham Beeches." By Francis George Heath. 8vo. London: Sampson Low, Marston & Co., 1879.

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

Brachycephalism and Civilization.—Professor Virchow has suggested that dolichocephalous races may become brachycephalous by the sole agency of civilization. To test this view, M. Luschan has undertaken a number of investigations into the contents of the great ossuaries of the German provinces of Austria, dating back to the fifteenth and sixteenth centuries, and communicated his results summarily to the French Association for the Advancement of Science (1878, p. 825). At Mödling, in Lower Austria, he found the crania of the fifteenth century of a very pure dolichocephalic type with a mean index of 68. The present population of the village is brachycephalous, with a mean index of more than 80.

Analogous results were obtained in many ossuaries in upper and lower Austria, in Carinthia, and in Salzburg. But in others, such as that of St. Peter im Holz, near Spital, in Carinthia, all the crania from the sixteenth century down to the present day were dolichocephalous. Now the population of St. Peter im Holz has the same schools, the same language, the same laws, and the same degree of civilization as that of Mödling; and it is consequently hard to say that at Mödling the crania have become brachycephalous by civilization, whilst under the same conditions, they have remained dolichocephalous at St. Peter.

There must therefore be another cause for brachycephalism being so prominent in many parts of the German provinces of Austria. According to M. Luschan, wherever brachycephalous crania are found, the state registers show Sclavonic names, and it may be ascertained in all cases either from history, or from the registers, that a more or less abundant Slav immigration took place into them during the sixteenth century. Some ossuaries in Bavaria have furnished the author with similar results. He regards it as certain that in Austria brachycephalism has been produced not by civilization, but by Slavs; and he thinks it very unlikely that the Prussians have acquired their remarkable brachycephalism solely by the influence of culture and civilization.

The Age of Stone in China, and the Chinese Origin of the Cremation of the Dead.—According to M. Zaborowski (*Assoc. Franc Avancem. Sci.*, 1878, p. 835), the age of stone was only a matter of tradition in China at the earliest period of history, and even then this tradition was coupled with

superstitions. The historians, however, state that Chin-noung (B.C. 2737), and Hoang-ti (B.C. 2697), still employed stone in the manufacture of their weapons. But as early as the reign of the latter prince, the rebel Tchi-Yeou of the country of Kiou-li made use of metallic arms. In the Chou-King it is stated that in the time of Yu (B.C. 2200), the savages near the rivers Ho and Kiang brought as tribute, *iron, silver, steel, and stone arrow-heads*. The last were therefore already regarded as rare and precious objects, as they were at a later period, to judge from an anecdote here related. In the year 495 B.C., Confucius being at the court of Tchin, a bird pierced by an arrow with a stone head, fell upon the terrace at the feet of the King, who seems to have been rather alarmed, and consulted Confucius on the subject. The philosopher told his majesty that the arrow-head was exactly like that which Wou-wang had presented as a symbol of royalty to the prince, for whose benefit he founded the kingdom of Tchin. The King, searching among the precious relics of his ancestors, actually found a stone arrow-head.

In the history of King-Tcheou, it is related that a block of granite existed in the district of Sin-ho, still having traces of the polishing of stone implements; the inhabitants called it "the dormant mill of the thunder god." It is curious to find this association of stone implements with thunder prevalent in China as in Europe. Among some pretended celestial presents brought to the Emperor Sou-Tsoung (A.D. 756–762) by a Buddhist priest, there were two fragments of jade forming a polished hache, which bore the designation, "stones of the thunder god." The very great antiquity of the civilization of China is regarded by M. Zaborowski as an additional proof of the great lapse of time that must have occurred since the use of stone implements was general there.

With regard to the cremation of the dead, M. Zaborowski remarks that this practice spread over Europe at the commencement of the Bronze age, and that it did not come to us from Egypt or Phœnicia, as neither the Egyptians nor the Phœnicians burnt their dead. On the other hand, cremation was practised in India from the most remote antiquity, and in China it appears that before the year 1122 B.C., straw men destined to be burnt were carried in funerals, but at that date these were replaced by wooden figures. Confucius refers to this change in terms which show the religious nature of the practice; he says: "Those who made *spirits* of straw were regular; those who made men of wood were irregular." The practice seems to symbolize a still older one of burning the body itself.

At the present day in China cremation is rare, and the remains of the dead are only burnt at the end of a year. But the practice prevails in Cochin-China; and in the time of Marco Polo it was in use all over the extreme east of Asia, where it may be supposed to have existed from the earliest times. From this same region, he believes, the bronze industry came into Europe.

Capacity of the Cranium in Man.—M. Anoutchine has found reason to doubt the absolute truth of the maxim that in the human species the most voluminous crania belong to the most intellectual races, and in each race to the most intelligent individuals. In support of this opinion he gives the following list of cubic contents from various authorities, but all taken by the same process:—

	Cub. cent.		Cub. cent.
Germans (Weissbach)	1,521	Russians (Lauzert)	1,471
„ (Welcker)	1,448	Tchuktchi (Wyman)	1,468
Croats (Weissbach	1,499	Slovaves (Weissbach)	1,467
Kalmuks (Metschnikoff)	1,498	Czèchs (Weissbach)	1,456
Chinese (Lucæ)	1,482	Hungarians (Weissbach)	1,437
Roumanians (Weissbach)	1,478		

The Kalmuks and Chinese have a greater volume of the cranium than several European nations, and the Tchuktchi are larger than the Hungarians. The large size of the heads of the Kalmuks has been observed by several voyagers, and proved by actual measurement by Metschnikoff and Von Baer.

With regard to the pre-historic races of Europe, M. Anoutchine thinks we cannot say absolutely that the volume of the cranium was less in them than in modern races. The mean volume of the cranium in modern Parisians is 1,558 cub. cent. (in the women, 1,337). Of pre-historic crania we have:—

		Cub. cent.
Cranium of Cro-Magnon		1,550
„	„	1,590
„	Grenelle	1,530
„	L'Homme Mort.	1,606
„	La Truchère (estimated)	1,925
„	Solutré	1,560
„	„	1,428
„	Furfooz, Young	1,300
„	„ Female	1,450

Thus these pre-historic people do not appear to have had a cranial capacity decidedly less than that of the existing Parisian. In the race of Canstatt, and the Neanderthal man, we have a different state of things, the latter being estimated to have had a cranial capacity of not more than 1,200 cub. cent. But this character may have been individual and exceptional, just as Kay Lysse, a Dane who played an important political part in his country, had a capacity of only 1,250 cub. cent.; and Luschan has measured the brain of a Hungarian of only 1,195 cub. cent.

As regards the difference in volume of the largest and smallest adult male crania, and its supposed increase with the civilization of the race, M. Anoutchine points out that although Le Bon has found this difference to be 592 in modern Parisians, and only 472 in the Parisians of the seventh century, whilst in the Australians it is only 284, Mantegazza has found a difference of 533 among the Papuas of New Guinea, and Metschnikoff one of 539 among the Kalmuks. Nor does he think it an absolute fact that the difference of volume between the male and female crania is much greater in civilized nations than among half-savage peoples. Thus Welcker finds, by the comparison of thirty crania of each sex, that the mean difference among the Germans is 148 (1448–1300), and Mantegazza gives it as 140 (1425–1285) among the Papuas. The two numbers approach closely, but the difference in the civilization of the two peoples is immense.—(*Assoc. Franç. Avancem. Sci.*, 1878, p. 863.)

Anthropometry.—The Anthropometric Committee of the British Association appointed for the purpose of making a systematic investigation of the heights, weights, and other dimensions of the human inhabitants of the empire, laid their report before the Association at the last meeting. They stated that considerable progress had been made in carrying out the objects of the Committee during the past year, returns having been obtained giving the birth-place, origin, and sex, age, height, weight, colour of hair and eyes girth of chest, and strength of arm and eye-sight, of a great number of persons, including pupils at Westminster and other schools, London policemen and letter-sorters, rifle volunteers, soldiers, and criminals. The Committee had thus procured nearly 12,000 original observations on the question of height and weight in relation to age, in addition to 50,000 previously collected. From tables embodying the results of these inquiries, it appeared that the London letter-sorters were the lowest in height, the average between the ages of 20 and 35 being 64-67·1 inches. They were also the lowest in point of weight, being only from 122·5 to 130·0 lbs. The metropolitan police stood at the head of both lists, height 69·2-71·5 inches, and weight 162·5-182·7 lbs. From other tables it appeared that the average of weight and height varies with the social position and occupations of the people, so that to arrive at the typical proportions of the British race, it would be necessary to measure a proportionate number of individuals of each class. Taking the census of 1871 as a standard, a model community should consist of 14·82 per cent. of the non-labouring class, 47·46 per cent. of the labouring class, and 37·72 per cent. of the artizan and operative classes. The nearest approach to such a representative population will be found in some of the larger county towns, such as York, Derby, and Exeter. In the professional class the full stature is attained at 21 years, and in the artizan class between 25 and 30 years. According to some American statistics a slight increase in height takes place up to the 35th year. The growth in weight does not cease with that of the stature, but continues slowly in both classes up to about the 30th year. Similar investigations which have been made in other countries have led so far to coincident results that it is hoped that, in course of time, information of great value will be elicited.—(*Nature*, 18 Sept. 1879.)

Date of the Neolithic Age. In a paper read before the Biological Section of the British Association, Mr. S. B. J. Skertchly propounded a new estimate of the date of the Neolithic Age, based upon calculations made in the Fenlands, occupying an area of 1,300 square miles, around the great bay of the Wash. The surface of the inland portions of this area consists of peat, and that of the seaward parts of marine silt. This silt is still in progress of deposition, and, from the time of the Roman occupation at least, banks have been successively erected to reclaim the newly-formed ground; and, as the dates of these banks are known, very accurate estimates can be formed of the rate at which the deposition is going on in different parts. The maximum rate is, according to Mr. Skertchly, fifty-nine feet per annum; and four miles of new land have been formed since the oldest banks were erected. These banks are generally ascribed to the Romans, but the author considers that they are probably British. In forming his estimate, he has, however, taken them as Roman, in order that their age may not be over-estimated, and the

maximum rate of deposition has also been used, as giving the minimum of time. He considers that the geological evidence shows that as the silting went on, and the area became converted into land, peat grew, and gradually spread over the newly-formed ground. But, in process of time, the climate became unsuited for the growth of peat, which gradually lost its vigour, and finally ceased to form. Hence a wide stretch of silt-land borders the Wash, upon the surface of which no peat has ever formed. The peat died upon its eastward march; the silt still travels on. The nearest approach of the peat to the banks along the line of most rapid accumulation, is twelve miles distant therefrom. The age of this, the newest peat in the Fenland, the author thinks can be thus determined. Between the "Roman" banks and the sea lie four miles of silt, which has taken 1,700 years to accumulate. Between these banks and the peat lie twelve miles of silt, which, at the same rate of formation, would take 5,100 years to accumulate. Adding 5,100 to 1,700 years, the author finds 6,800 years as the least possible age of the newest peat. This peat has yielded many neolithic implements; hence we may assume that 7,000 years will take us back into the neolithic age. The author remarks upon the coincidence of this estimate with two Swiss ones previously referred to, but observes that these results do not give us the date of the introduction of neoliths into Europe, for neither in the Swiss nor English localities are we sure that the neolithic relics belong to the early part of the neolithic age. The author further states that he has recently obtained evidence of neolithic handiwork in Fenland peat of far greater age than that described; the peat-bed underlying silt more than 7,000 years old. He is inclined to think that the neolithic age in England began at least 10,000 years ago—and perhaps 20,000 years; but that it does not approach the close of the glacial epoch, he thinks is shown by the fact that the older Fenland beds (themselves in part glacial) do not contain human relics.

ASTRONOMY.

Biela's Comet.—It is well known that when this comet returned to perihelion in 1866 and again in 1872, the heavens were searched in vain for it, by many of the most careful and trustworthy observers. It seems exceedingly unlikely that telescopists will meet with greater success this year. Calculation seems set completely at defiance. In the first place it is to be remembered that every return of this comet increased the accuracy with which its orbital motions were known. So that as it had been at once identified in 1846 and again in 1852, astronomers had every reason to expect that it would be much more easily found in 1866 (in 1859 its geometric path brought it too near the sun's place in the heavens for a successful search to be instituted). In 1872 the chance of finding it had only so far diminished, that the failure of astronomers showed that something had gone wrong. There was good reason to believe that the failure to recognize the comet did not in any way arise from unknown perturbations to which the comet had been subjected, but from a further disintegration of the comet's substance, already so far effected that since 1846 this object had in reality become

two distinct comets. Now some ten or twelve months after the comet had (according to the calculations of astronomers) passed the part of its orbit which intersects the earth's track (or at least passes very close to it), the earth herself came to the corresponding part of her orbit—that namely which she passes on or about November 26, 27, and 28. There then occurred, as had been predicted by Professor Alexander Herschel, a shower of meteors, in which some tens of thousands of small shooting stars were seen, radiating from a part of the heavens near the feet of Andromeda, and thus corresponding with the course which bodies following in the track of Biela's comet would pursue on the sky if they entered the earth's atmosphere when she is in the part of her orbit crossing Biela's. Klinkerfues, assuming that this cloud of meteors was Biela's comet itself, telegraphed to Mr. Pogson, Government Astronomer, at Madras, to examine the part of the heavens—near Theta Centauri—towards which the meteors were moving. Pogson did so, and saw in that part of the heavens two cloud-like objects moving along a course corresponding with that which attendants of Biela's comet would have followed as viewed from the earth. Now Mr. Hind, in discussing the question of the possible rediscovery of Biela's comet, takes as a probable assumption that the comet really touched the earth on November 27, 1872. "Intersecting, or at least passing very near to, the earth's orbit, on November 27," he says, "the comet must have been descending to a perihelion passage a month later, or about December 27·6; such at least would be the date when the meteoric shower would arrive at its least distance from the sun. In this fact appears the only ground upon which we can now work to obtain an idea of the probable position of the comet in the present year." Then, having given the most probable elements of the orbit of Biela's comet as determined from the observations of 1846 and 1852, he says that if the meteoric cloud of November 27, 1872, was moving in this orbit, "a revolution counted from December 27·6 in that year will bring us to about September 8, 1879, as the epoch of next perihelion passage. Assuming September 7·5, we should have the following sweeping-line for that date:—

Time from perihelion. Days.	Right ascension.	North declination.	Distance from earth.	Intensity of light.
0	140°·2	10°·8	1·66	0·47
−20	125·9	17·4	1·42	0·57

"It may, however," he proceeds, "be regarded as by no means improbable that the perihelion passage of the body which caused the shower of meteors may take place much later, and a very close and extended search will be required."

It should be noted, however, that the display of meteors seen on November 27, 1872, was by no means such as to suggest that the cloud of meteorites would be discernible as a nebulous object by reflected light. Again it seems certain that the two nebulous objects seen by Pogson, were not travelling as that meteoric cloud would have travelled; this was very clearly and satisfactorily shown early in 1873 by Captain Tupman. And if we suppose that either Pogson's nebulous clouds, or the meteoric flight, were Biela's comet, the delay of ten or twelve weeks is quite inexplicable by any possible perturbation, seeing that a cause effective enough to have made a difference of

ten or twelve weeks in the time of perihelion passage, would have entirely altered the character of the comet's orbit, whereas the only circumstance that enabled astronomers to identify the meteors of November 27, 1872, as attendants on Biela's comet and following in its track, was the observed agreement of their motions with those of bodies so travelling. On the whole, while it seems to us exceedingly probable that Andromeds or attendants on Biela's comet will be seen on the night of November 27, or perhaps a day or so earlier or later, we believe there is scarcely any, if any, chance whatever, of rediscovering the comet itself. The search ought to be made rather (we may now rather say, should have been made) where the comet should be seen, if not too completely dissipated, than where the meteoric flight, or either of Pogson's clouds, might be if really following in the track of the comet. We trust that small though the chance may be of obtaining fresh information respecting this remarkable comet, astronomers will watch carefully for the November Andromeds. As Hind says, "there is great justice in M. Otto Struve's remark: 'Kein Comet gebe mehr Ansicht über die Natur der Cometen im Allgemeinen etwas zu erfahren, als der Biela'sche.'"

Solar Parallax deduced from Observations of Mars.—Mr. Gill gives as the result of his observations of Mars, during the opposition of 1877 (it will be remembered that Mr. Gill visited Ascension Island to make these observations) a solar parallax of 8.″78 ± 0.″015, corresponding with a solar distance of about 93,093,000 miles. This distance is considerably greater than that which Professor Newcomb regards as the most probable mean (about 92,400,000 miles) of all the best observations. It agrees well with the distance resulting from the combination of Struve's constant of aberration with Cornu's determination of the velocity of light; but the constant of aberration can hardly be regarded as determined with a degree of accuracy sufficient to enable us to determine the real distance as accurately as by other methods, even if Cornu's determination of the velocity of light be considered trustworthy, within the necessary limits. On the whole, the result of Mr. Gill's observations will probably be regarded by most astronomers as disappointing, simply because it was hoped that it would serve to remove doubts as to the sun's true distance, instead of increasing them. But whether this is due to error in other estimates, or to the inferiority of the method used by Mr. Gill, is a point on which we should not care to express an opinion.

Tidal Theory of the Evolution of Satellites.—Mr. G. H. Darwin has suggested a theory of the evolution of satellites which is worth careful consideration. But it is vitiated so far as his treatment of the matter is concerned by an assumption the reverse of the truth. He remarks that if a planet were formed of fluid, it would assume a spheroidal shape under the influence of the planet's rotation, but if a satellite revolves in a circular orbit round the planet in the plane of the equator, tides will be raised in the planet, such that the spheroid will become distorted into an ellipsoid with three unequal axes, and the longer axis of the equator will always be directed towards the satellite. Thus the shape of the planet revolves along with the satellite, whilst each particle of fluid revolves with the planet, and has therefore to rise and fall twice in every revolution of the planet relatively to the satellite. Starting from this position, and taking into account the effects of friction,

Mr. Darwin arrives at the conclusion that the moon and earth originally formed part of the same body, and gradually separated into two; the present order of things having arisen from the tidal effects subsequently produced on each other by the two portions of what had once been a single mass. How far this theory would have to be modified if the dynamical theory of the tides be substituted for the statical theory thus made the basis of Mr. Darwin's reasoning, we have not yet ascertained. But it is certain that a rotating fluid mass, such as the planet is in the very beginning described to be, would not, apart from frictional effects, assume the form described by Mr. Darwin. On the contrary, the longer axis would lie in a direction at right angles to the line joining the centres of the planet and its satellite, for precisely the same reason that the orbit of the moon around the earth has its curvature increased at the quadratures and diminished at the syzygies. There is an excellent explanation of this, the true theory of tide in a frictionless ocean, in Sir Edmund Beckett's "Astronomy without Mathematics." Another was given by Sir George Airy in a paper read before the Astronomical Society, the substance of which (with the illustrations) will be found in the "Popular Science Review," vol. v. pp. 356, 357. The writer of the astronomical summary then described the explanation as "a very beautiful geometrical proof that, contrary to generally received notions, were the tides to move without friction, there would always be low water under the moon."

Babylonian Astronomy.—In the last four numbers of the "Notices of the Astronomical Society," there is an interesting paper (described as preliminary only) by Professor Sayce and Mr. Bosanquet, on ancient Babylonian Astronomy. We need not here consider the nature of the Babylonian calendar, because much space would be required duly to elucidate the subject. But there are some points relating to the identification of stars which may be noticed as apparently requiring further examination by the authors of the paper. It appears that the inscriptions are written in at least two languages —Assyrian and Accadian; and "everything has in consequence two names at least, though these are generally represented by the same character." This is an obvious source of difficulty. But still more likely to mislead is the circumstance that "the planets frequently assume the names of stars in whose neighbourhood they were observed." It will be manifest that extreme care must be taken in the investigation of Babylonian records of observations, under this perplexing system. Professor Sayce and Mr. Bosanquet consider only in their present paper a star called Icu or Dilgan, the former name being Assyrian, the latter Accadian, and signifying the "messenger of light." This star was used to determine the arrangement of lunar months in each year. Thus the following rule is given: "When on the first day of the month Nisan the star of stars (or Dilgan) and the moon are parallel, that year is normal" (or has twelve months); "When on the third day of the month Nisan the star of stars and the moon are parallel, that year is full" (or has thirteen months). This inscription is in Accadian, the most ancient language of the inscriptions. "It may be expected to belong to a time earlier than 2000 B.C." From this rule the authors of the paper deduce the conclusion that Dilgan, the "star of stars" or the "messenger of light," is Capella. Now Capella is a very fine star, but unless it has diminished wondrously in lustre in recent times, it could

scarcely have deserved to be called the "star of stars." It is also too far from the ecliptic to be used conveniently as a regulator of the calendar. On the other hand, we must not be misled by the name "messenger of light" to suppose Dilgan identical with Venus, whose orb has been called Phosphorus and Lucifer (each name signifying the "light-bringer"), for manifestly no planet could be used, as Dilgan was, to regulate a lunisolar calendar. We should be disposed to infer that the "star of stars" was the Pleiades, if evidence can be found for the use of the Accadian word for star to signify also a star-group (as *astrum*). We have every reason to believe that the Pleiades were used to measure the year, and from the position of this star group near the ecliptic it would be far better suited than Capella for the purpose indicated in the above-quoted rule.

Opposition of Mars.—Mr. N. E. Green, who did such good work in the observation of Mars at the last opposition, calls attention to the desirability of careful observations of the planet during October, November and December next. This will be the most favourable opportunity for many years for examining the details of the equatorial continents. "A careful search should be made for the remarkable dark canals figured by Professor Schiaparelli, which are represented by him as connected with the bays of the Sea of Maraldi and the Strait of Herschel, especially with the two points of Dawes's Forked Bay. The northern declination of Mars will compensate in great measure for the reduction in its diameter when compared with that of last opposition, and every use should be made of this occasion for the re-examination of previous drawings." The astronomers of the Washington Observatory point out that the satellites can hardly be seen, even with the most powerful telescopes, except for a few weeks before and after opposition. It is to be hoped that those capable of taking part in the search for these minute and most difficult of telescopic objects will spare no efforts to obtain exact and trustworthy observations, whereby the theory of the Martian satellites may be advanced as far as possible.

The Planets for the Next Quarter.—Saturn comes to opposition on October 5th, at 11 P.M.; Neptune on November 3rd, at 10 A.M.; and Mars on November 12th, at 8 P.M. On October 6th Mercury will be in superior conjunction with the sun; Venus at her greatest brilliancy as a morning star on October 31st.

Partial Eclipse of the Moon.—There will be a partial lunar eclipse, visible at Greenwich on the evening of December 28th; first and last contacts of the shadow will occur at 3h. 37m. and 5h. 15m. respectively. The magnitude of the eclipse, lunar diameter as 1, will be only 0·167.

BOTANY.

Fertilization of Red Sea-weeds by the Agency of Infusoria.—Professor Dodel-Port, of Zurich, has communicated to "Kosmos" an account of some exceedingly interesting observations made by him on the fertilization of a Floridean Alga, *Polysiphonia subulata*, T.Ag., which appears from his researches to present a singular combination of analogies with the anemophilous and entomophilous phanerogamous plants. An abstract of Professor

Dodel-Port's paper, with figures, appears in "Nature" of September 11. Like many other Florideæ, *Polysiphonia subulata* is diœcious, and the male and female plants appear often to grow at a considerable distance apart. The antherozoids, which are produced from antheridia presenting a considerable external resemblance to microscopic ears of maize, are described as mere globules of protoplasm, containing a small highly refractive nodule and a few plasma granules, but entirely destitute of cell-wall, and consequently of the cilia, by means of which the antherozoids of so many Algæ make their way through the water in search of the female organs which they are destined to fertilize. The antherozoid is thus precisely analogous to the pollen grain of an anemophilous phanerogamous plant.

The female reproductive organ in this plant is a multicellular body forming an outgrowth from the apical parts of the branches of the thallus. The youngest of these carpogonia is found nearest the apex, those lower down being more mature. The structure of the carpogonium is described by Professor Dodel-Port in detail, but the most important point for our present purpose is the presence at its summit of two hair-like organs—a forked hair composed of several cells; and a trichogyne, a slender, colourless, unicellular hair, a little shorter than the forked hair, and produced from the surface of the carpogonium at a later period, making its appearance, in fact, about the time when the unfertilized carpogonium arrives at maturity. When full grown it is of a cylindrical form, abruptly rounded off at the extremity, and its narrow interior canal is filled with colourless, finely granular protoplasm. The trichogyne is most important, as it is the receptive organ, analogous to the elongated style which occurs in so many phanerogams. Fresh antherozoids of *Polysiphonia subulata* on coming into contact with the upper part of the trichogyne, which seems to some extent to act as a stigma, immediately adhere to it firmly, when the granular contents of the antherozoid pass into the interior of the trichogyne, and a part of them descending the canal in the latter reach the carpogonium, of which they fertilize the central cell. This process, as will be seen, is very analogous to that which takes place in phanerogamous plants.

In the case of anemophilous or wind-fertilized diœcious plants it is well known that the chance of fertilization is usually greatly increased by the enormous quantity of pollen which the male flowers yield to every passing breeze, and a similar provision is found to prevail in the case of the diœcious *Polysiphonia*. It is perfectly clear that the antherozoids of this plant, being quite destitute of any locomotive organs, must be passive in their further proceedings, and they are no doubt carried along in all directions by the currents, and other movements of the water, until, on meeting with the trichogyne of the female plant, they adhere to it, and fulfil their duty. When the two sexes grow at no very great distance apart, Professor Dodel-Port seems to think that the small marine animals, crustacea, annelids, starfish, infusoria, &c., which swarm in the submarine forests of Florideæ, may aid importantly in effecting the transportation of the fertilizing element to the female organ, but in the course of his investigations, he discovered that certain minute animals interfere in the process in a much more curious and interesting fashion, vividly reminding us, indeed, in the singular adaptation of means to ends, of the wonderful relations unquestionably existing

between insects and flowering plants. On the growing thallus, and especially on the youngest branches, Dr. Dodel-Port, constantly found an immense number of the well-known Bell-Animalcules (*Vorticella*), which were, as usual with them, in incessant motion. These little creatures were found to feed upon the antherozoids floating about in the water; but, besides those which they manage to swallow, a considerable number are whirled about in the vortex caused by the cilia of the animalcule, which no doubt stops them in the course impressed upon them by larger submarine currents, and keeps them as it were hovering about the neighbourhood where their business lies. As the *Vorticellæ* are constantly changing their position by the contraction and extension of their little footstalks, the whirls set up by them in the water must become very complex, and the best proof that the action of these little vortices upon the antherozoids is beneficial to the plant, is to be found in the fact that it was through their agency that the author was enabled to observe the attachment of the antherozoids to the trichogyne. The presence of the *Vorticellæ*, in fact, imparts to the passive antherozoids a motion analogous to that with which the ciliated sperm-cells of other Algæ are endowed. In the case of this *Polysiphonia*, the beneficial action of the whirls produced by the *Vorticellæ* is supposed to be increased by the presence in the immediate vicinity of the trichogyne of the forked hair above-mentioned. This hair, it is believed, will divide the whirls, and thus produce subsidiary whirls, tending directly to bring the antherozoids into contact with the trichogyne. In his conclusion Dr. Dodel-Port has the following remarks:—"The total absence of active organs of locomotion in the antherozoids of Florideæ, points to a common ancestor from which the different branches of the Florideæ have inherited the immobility of the antherozoids. During the differentiation of the red seaweeds, many forms have no doubt died out in consequence of fertilization not taking place through the passivity of the male cells, while other forms have retired to localities which favour the process of fertilization by the active currents of the water, in spite of the immobility of the antherozoids. It is well known that we now find most of the existing species of Florideæ on the coasts of the warmer seas, which are constantly washed by the waves, while the northern coasts, which are covered with crusts of ice during a great portion of the year, are very poor in red seaweeds. Future researches will have to show how far in many of these aquatic plants the differentiation of the genera took place in the direction of an adaptation to the small marine animals which inhabit them, and favour their fertilization in the way I have pointed out."

CHEMISTRY.

Norwegium.—This name has been given by Dr. Tellef Dahll to a newly discovered metal occurring in the copper-nickel, and nickel glance of Oteroë, a small island near the town of Krageroë, Skjœrgaarden, in Norway. The mineral is roasted, the product dissolved in acid, and precipitated by sulphuretted hydrogen, and the well-washed precipitate, free from nickel, again roasted. The product thus obtained is the crude oxide of Norwegium.

It is next to be dissolved in aqua regia, and precipitated with the right amount of potash (in excess of the reagent the oxide redissolves), whereby an emerald green precipitate of Norwegium hydrate is obtained. This has now to be reduced with carbon or hydrogen. The metal is white, pretty malleable, of the hardness of copper, melts at a low red heat, has a density of 9·44, is soluble with difficulty in hydrochloric acid, but readily so in nitric acid; the solution is blue, and when diluted becomes green; the metal is also soluble in dilute sulphuric acid. The atomic weight appears to be, as a mean of two not very well according determinations, Ng = 145·95 if the oxide be regarded as NgO. As characteristic re-actions the following are given. The solutions of the metal are precipitated by potash, ammonia and sodium carbonate; the precipitates are green, and re-dissolve in an excess of the reagent, forming a blue solution. Sulphuretted hydrogen gives even in very dilute solutions a brown precipitate insoluble in ammonia sulphide. Before the blowpipe in the oxidizing flame in the borax bead, it gives a yellowish green colour which cools to a blue glass; in the reducing flame the blue colour is brighter; in a bead of phosphorus salt it shows a yellowish green which on cooling turns first an emerald green, then violet, and then to a blue glass. The oxide is easily reduced with soda on charcoal.—(*Compt. rend.* 1879, ii. xxxix. 47.)

Uralium, a New Metal of the Platinum Group.—As far back as 1869, A. Guyard discovered this metal in commercial platinum obtained from Russian ores. Next to silver it is the whitest metal known. Its malleability is as great as that of the purest platinum, but its ductility is much greater, and it is almost as soft as lead. Its melting point lies near that of platinum, and it is not volatile. Its specific gravity is 20·25, and its molecular volume, like those of osmium, platinum, and palladium, is 6·25. Its atomic weight has been found to be 187·25. In its chemical properties it is difficult to distinguish from platinum.—(*Monit. Sc. Quesneville*, July, 1879.)

Scandium, a New Earthy Metal.—L. F. Nilson announces the discovery of a new metal to which he has given the name of scandium. (*Ber. deut. chem. Gesellschaft*, 1879, No. 6.) It has been separated from ytterbia, but has not yet been obtained in a state of purity: it is the oxide in a white earth, which gives no absorption bands. After ignition it is attacked but slowly by dilute nitric acid, but more readily by hydrochloric acid. The solution of the nitrate is completely precipitated by oxalic acid. The nitrate is completely decomposed at a temperature at which ytterbium nitrate is only partially resolved into a basic salt. The atomic weight, calculated on ScO, must be below 90. The author doubts, however, this composition of the oxide, and thinks the formula ScO_2 more likely to be the correct one. Scandium would then rank between tin and thorium, and with an atomic weight of about 170 would occupy the vacancy intervening between 118 and 234.

"*Allotropic Copper.*"—Wiedemann has sought to refer the peculiar comportment of copper obtained by electrolysis from solution of its acetate, to its containing a considerable quantity of copper oxide. Schützenberger, who described it, adhering to his original view, states that the metallic deposit first obtained does contain much oxide, but in that which is afterwards obtained he found less than 5 per cent. of the oxide. His "Allotropic

Copper" thus formed, is not a blackish-brown mass such as Wiedemann obtained, but is bright, lustrous, and bronze-coloured; it oxidizes very quickly in the air, acquiring a beautiful indigo-blue lustre; when treated with dilute nitric acid, it evolves nitric oxide only; its density is considerably less than that of an equal amount of a mixture of copper and oxygen. Finally it changes, without loss of weight, into ordinary copper, if preserved without access of air, and the change takes place rapidly at 100°.—(*Bull. Soc. Chim. Paris*, 1879, xxxi. 291.)

The Gray Modification of Tin.—A window in the church of Freiberg, which had long been built up, was recently opened, when a wooden box was found in a good state of preservation, and enclosing a medal and a number of rings. The box may have lain in the niche three or four hundred years. The shaking which it underwent during removal from the niche sufficed to break the medals and the rings into a great number of pieces, some of which came into the possession of Arnulf Schertel, who has published the results of an examination of them.—(*Jour. prakt. Chem.*, 1879, xix. 322.)

The rings, which are 15 mm. in diameter, and 2 mm. in thickness of metal, are, like the medal, cast. The colour is a reddish blue-gray, the fracture uneven, but in the case of some fragments distinctly columnar. The metal is tin of great purity, free from lead, and containing a trace only of iron and sulphur. It is so fragile that it can be broken between the finger nails. By merely pouring hot water on the fragments they acquire a brighter colour, and a very considerably greater cohesion. Strong pressure, or a severe blow brings out a whiter colour. This tin has undergone the molecular change observed by O. L. Erdmann in organ pipes, composed of tin containing some lead, and by J. Fritzsche of St. Petersburg, in blocks of Banca tin. The determinations of the specific gravity of the metal made with great care gives the numbers 5·809, 5·781, and 5·803; fragments were next placed in hot water, and left there for some time until they acquired a bright colour. The specific gravities then determined were found to be 7·280 and 7·304. The gray modification increases in density by treatment with hot water, and acquires that of melted tin. Specimens of the gray tin described by Fritzsche were found to leave a density of 6·020, 6·002, and 8·930, but after treatment with boiling water it rose to 7·24 to 7·27. A specimen of the St. Petersburg gray tin was exposed in a glass vessel to the temperature of boiling ether, 35°, for one hour and a half, at the end of which time it had acquired a white hue, and the density of 7·23. A quantity of the Freiberg gray tin was exposed in the same way for three hours; its density remained 5·77, and its colour showed no change. When acetone was employed in place of ether, and the temperature thereby raised to 50°, the brighter hue was at once remarked, and after exposure for a short time to a temperature of 50°, its specific gravity rose to 7·279. To test the difference in chemical action of the gray and white modifications of tin, the following experiment was made. Two large fragments of rings were taken, and a platinum wire attached to each piece. One was converted into white tin, by immersion in boiling water, and then both were attached by means of platinum wires to a galvanometer. The gray variety was electronegative towards the white variety when dipped in dilute potash solution, in hydrochloric acid, or sulphuric acid; electropositive in dilute sulphuric acid.

The gray tin, therefore, is somewhat passive. It is a curious fact that among the gray rings contained in the wooden box were five rings having the colour and characters of ordinary tin.

The Source of the Hippuric Acid in the Urine of Herbivorous Animals.—A number of chemists have taken up this question with little effect. Hallwachs sought in vain for benzoic acid in hay, and found no substance in any way related to it. It is pointed out by Loew (*Jour. prakt. Chem.*, 1879, xix. 309), that Hallwachs did not search for kinic acid, and that Lautemann has long since suggested that this substance may be present in hay, as it is pretty plentiful in the vegetable kingdom. This Loew now finds to be the case. If hay be moistened with cold water and allowed to stand for 24 hours, and the contents be precipitated with lead acetate, and the well-washed precipitate be treated with sulphuretted hydrogen, a liquid is obtained which has now to be treated with milk of lime in excess to remove the phosphoric acid. The concentrated filtrate is then made hot, and while so, mixed with hot alcohol whereby the lime kinate is separated as a viscous mass. Further treatment consists in throwing down the lime with oxalic acid, and again adding alcohol to the concentrated liquid, whereupon the acid separates slowly in small granular crystals. Six grammes of kinate were obtained from one kilogramme of hay. When distilled with manganese peroxide and sulphuric acid it evolved kinone. The kinates are very soluble in water, and readily precipitated by dilute alcohol.

Action of Hydrogen on Carbonic Oxide in the Presence of a Red-Hot Platinum Wire.—J. Coquillion has found when moist carbonic oxide is passed over a red-hot platinum wire many times backwards and forwards, a change of volume is noticed which, when the gas was shaken with potash, disappeared, to appear again, however, as soon as the operation was renewed, until finally nothing is left but nearly pure hydrogen. The change noticed must take place in accordance with the equation—

$$CO + H_2O = CO_2 + H_2.$$

The presence of nitrogen does not interfere with the change. The conversion of carbonic oxide into carbonic acid, during the decomposition of water vapour, cannot take place all at once, for between the CO, CO_2, H and H_2O, a state of equilibrium is set up, which limits the action. A moist mixture of 31·50 volume per cent. of carbonic oxide, 8·08 per cent. of hydrogen, and 60·42 per cent. of nitrogen, increased in volume 10 per cent., and was changed into 21·3 per cent. of carbonic oxide, 10·00 per cent. of carbonic acid, 18·08 per cent. of hydrogen, and 60·62 per cent. of nitrogen. Pure carbonic oxide increased 30 per cent. in volume, and the mixture consisted of carbonic acid 30 per cent., hydrogen 30 per cent., and carbonic oxide 70 per cent. The author made these experiments during some investigations of the gas found in Siemens's generative furnaces. They were fed with coke, and it was not possible to convert the whole carbonic acid into carbonic oxide, however high the layer of ignited coke be made. The vapour of water contained in the latter takes part in the reaction by reoxidizing the carbonic oxide. The greater its quantity the higher rose the percentage of carbonic acid and of hydrogen. This reaction takes place in smelting furnaces. Ebelmen held that hydrogen acted directly as coke,

while it is evident from the above that it is in reality carbonic oxide which enters into the reaction.—(*Compt. rend.*, 1879. lxxxviii. 1204.)

Reduction of Potassium Perchlorate.—Tommasi finds that this substance is not reduced by zinc, cadmium, magnesium, or aluminium, either in acid or in alkaline solution, at ordinary temperature or at 100°. Moreover it is not acted upon by sodium amalgam, nor reduced by ferrous hydrate. When the acetate of lead or copper is reduced by these metals, this salt, if present, undergoes no change. The perchlorate is, however, converted into chloride readily and at moderate temperatures, if mixed with sodium bisulphite, and acted upon with rods of zinc. The hydrosulphite produced by this reaction is converted into sulphite at the expense of the oxygen of the perchlorate, in accordance with the following reaction—

$$4SHNaO_2 + ClKO_4 = ClK + 4SHNaO_3.$$

No hydrogen is evolved. Towards the end of the reaction hyposulphite is also found—

$$2SHNaO_2 = H_2O + SNa_2O_3S.$$

—(*Ber. deut. chem. Gesell.*, 1879, xii. 1701.)

The Direct Combination of Cyanogen and Hydrogen.—Gay-Lussac was unable to cause these substances to unite directly, either by the application of heat, or by the electric spark. In his day the influence of time on certain chemical reactions had not been studied. Berthelot therefore has repeated the experiment. It is now many years since the author showed that in a mixture of cyanogen and hydrogen, through which electric sparks had been passed, acetylene and hydrocyanic acid were formed. It cannot be clearly seen from this whether the substances directly unite, or whether acetylene be not first formed, and nitrogen separated, and hydrocyanic acid is not subsequently produced. A quantity of dry cyanogen and hydrogen in equal volumes were passed through a tube heated to 500°–550°, and a partial combination was at once noticed. The escaping gas contained 47 to 48 per cent., instead of 50 per cent., of free hydrogen. In closed tubes this reaction took place more readily. After they had been heated for several hours, and were opened over mercury, a contraction of volume amounting to one-seventh was reached, due probably to the formation of paracyanogen. Potash quickly absorbed five-sevenths, and the remaining seventh consisted of nearly pure hydrogen. The reaction, therefore, had taken place in accordance with the equation: $Cy + H = HCy$. The process is quite analogous to that by which hydrochloric acid is produced, with the difference that it takes place more slowly, and at a higher temperature. At lower temperatures it goes more slowly; at higher, nitrogen is set free. Zinc, cadmium, and iron, heated with cyanogen in tubes to 300°, formed cyanides of those metals, and no cyanogen was decomposed. Zinc, even at ordinary temperatures, is acted upon by cyanogen after several days exposure to it; at 100°, after the lapse of some hours, an absorption of the gas is remarked. Cadmium is passive in the cold, and at 100° only traces of cyanogen are absorbed. Iron is passive at 100°; silver and mercury are passive at all temperatures. The synthetic formation of hydrocyanic acid, whether by the combination of cyanogen and hydrogen in equal volumes without condensa-

tion, or by the combination of acetylene with nitrogen, also in equal volumes without condensation,

$$C_2N + H = C_2NH \; ; \; C_2H + N = C_2HN,$$

points to a striking relation between these two bodies, regarded as compound radicals.—(*Compt. rend.*, 1879, lxxxix. 63.)

GEOLOGY AND PALÆONTOLOGY.

American Jurassic Mammals.—Professor O. C. Marsh has discovered some interesting remains of small mammals of Jurassic age, in the so-called "Atlantosaurus beds" of the Rocky Mountains. All the specimens are lower jaws, as is general in our own Stonesfield and Purbeck deposits, and they have enabled their discoverer to distinguish four species. Two of these he regards as Marsupials, but as belonging to a peculiar genus, *Dryolestes.* One specimen possesses the strongly inflected angle characteristic of marsupial mammals; another shows that the number of premolar teeth was at least four, showing that the genus is quite distinct from *Didelphys.* Professor Marsh names the species, both of which were of small size, *Dryolestes priscus* and *D. vorax.* A third species is represented by the left side of a jaw, the two extremities of which are either wanting or badly preserved. It is remarkable for the great number of molar and premolar teeth, which are apparently at least twelve in number, and possibly more. Some of the premolars have two fangs; all the molars are single-fanged; the former have compressed and recurved, and the latter conical crowns. A large pointed tooth lying near the jaw is regarded as probably a canine. The animal, which was somewhat smaller than a weasel, and probably insectivorous in habits, presents close resemblances to the genus *Stylodon* of Owen, from the English Purbecks, with which Professor Marsh thinks it may constitute a distinct family, Stylodontidæ. He names it *Stylacodon gracilis*, the specific name being in allusion to the slenderness of the jaw. A fourth form is said to resemble in some respects the genus *Triconodon* of Owen, the molar teeth having each three pointed cones; but there are four such teeth instead of three, and the middle cone in each tooth is larger than the others. The angle of the jaw is much produced but not inflected; the author nevertheless regards the little animal as having been probably an insectivorous Marsupial, allied to *Triconodon* and *Phascolotherium.* He names it *Tinodon bellus*, and suggests that the uninflected angle of the jaw, and the position of the coronoid process, which ascends at right angles to the ramus immediately behind the last molar, would indicate that it forms the type of a new family (Tinodontidæ), if not that it may have been a placental mammal. —(*Silliman's Journal*, July and September, 1879.)

Pélé's Hair.—Professor Dana publishes some notes on the curious fibrous product of the crater of Kilauea, commonly known by the above name, founded on a supposition of the natives that it was the hair of their goddess Pélé. Professor Dana gives two new analyses of this substance, which are very nearly accordant. Their mean shows a composition almost precisely that of ordinary dolerite, as shown in the following comparative statements:—

	Pélé's Hair	West Rock "Trap"
SiO^2	50·75	51·80
AlO^2	16·54	14·21
FeO^2	2·10	3·55
FeO	7·88	8·26
MnO	trace	0·42
MgO	7·65	7·63
CaO	11·96	10·68
Na^2O	2·13	2·15
K^2O	0·56	0.39
ign.	0·35	0·63
Total . .	99·92	99·72 + PO^5 0 14.

This "trap" consists of labradorite and augite, with some magnetite, and the perfect fusibility of such a compound is well indicated by the facts observed at Kilauea. There is hence no question as to the complete fusion of such ingredients in a volcano, even where no moisture is present. "The analyses," says Professor Dana, "add another to the many examples already known, proving that there was no difference in constitution between a large part of the material in fusion rejected in mesozoic time, and that thrown out by modern volcanoes; and it illustrates the fact that geology has no good basis for the distinction of 'older' and 'younger' among igneous rocks."

According to C. F. W. Krukenberg, the fibres of Pélé's hair are often tubular, and sometimes bent and formed into loops; they frequently contain air-bubbles, and occasionally microlites. They are usually enlarged where they contain crystals (or microlites), and also about many of the air-cavities.—(*Silliman's Journal*, August, 1879.)

Palæozoic Plants.—Count Gaston de Saporta notices certain organisms of Lower Silurian age, the nature of which has hitherto been very doubtful, as they have been regarded by different observers sometimes as vegetable impressions, sometimes as casts of the tracks of annelides or other animals. Three types are especially referred to by M. de Saporta, namely, *Tigillites*, *Bilobites* or *Cruziana*, and the Scandinavian *Eophyton*. *Tigillites* are regarded by him as representing the tubes of arenicolous annelides. They are cylindrical bodies associated in colonies, placed vertically in the rocks, and filled in after the death of the inhabitant. In appearance and dimensions, in the presence of obscure zones of growth still visible on the surface, in the mode in which they terminate below, and, in fact, in all their characters, they resemble the *Spirographis* now living on the shores of the Mediterranean.

Bilobites or *Cruziana* is regarded as a marine vegetable organism, although nothing analogous to it exists among the Algæ of the present day. M. de Saporta adduces, in support of the vegetable nature of these fossils, a peculiarity in their mode of fossilization. They are found in half-relief upon the lower surface of the beds in which they are preserved, and are always represented by a hollow impression on the upper surface of the subjacent beds. This half-relief, showing all the details of the external organization of the ancient plants, is the result of the imbedding of a fleshy or cartilaginous body which, after moulding itself in the sediment, has disappeared by de-

composition. The pressure of the beds in course of formation would then fill up the lower half of the mould, forming the cast in relief. The *Cruzianæ* consist essentially of two convex parts united in the middle line, and marked on the surface with oblique sinuous striæ. Their extent renders it impossible to trace their whole length, or to obtain an entire individual with the superior termination of the frond. Nevertheless, from a number of remarkable impressions collected by Professor Morière of Caen, we see that the lines of junction, which are at first simple, afterwards become complicated by ramification, and produce at the summit a goffered, sinuous expansion. At many points on the surface of the phylloma of *Cruzianæ* scars of insertion are observed, which seem to be produced by radicles or organs of fructification, leaving, when shed, the traces of their attachment.

The *Eophyta* are cylindrical bodies (stems or phyllomata). They are more or less elongated, perhaps ramified above, or dilated and laterally compressed, and always marked with regular striæ and fine channels running longitudinally, and often resembling nervures. They have no resemblance to the *Cruzianæ*, and the two types must have constituted distinct genera, if not families. Neither of them can be regarded as nearly related to any existing *Algæ*, but they may be regarded as extinct types very distantly allied to the Caulerpeæ.—(*Assoc. Franç. pour l'Avancem. des Sciences*, Séance de 1878, p. 576.)

Volcanic Products at the bottom of the Pacific.—The Abbé Renard, and Mr. J. Murray communicated to the Geological Section of the British Association, at Sheffield, the results of an examination of the materials brought up by the *Challenger's* instruments from the bottom of the central Pacific. The area from which the materials submitted to the Abbé Renard were derived, extends from the Sandwich islands to 30° S. lat., having the Low Archipelago approximately in its centre. Volcanic matter was found to play an important part in the formation of the bottom, being present in the form of lapilli and ashes distributed in great abundance in the "red clay," of which we have heard so much. The lapilli nearly all belong to the basaltic type, passing from felspathic basalt to allied rocks, in which the vitreous base acquires greater and greater development, until it almost entirely displaces the crystalline constituents of the basalt, when the fragments become mere glassy rocks of the basic series, generally containing some crystals of peridote, innumerable crystallites, the latter sometimes grouped in opaque granules, sometimes arranged regularly around the peridote microlites. From the forms of these volcanic fragments, which are often coated with manganese, their association with volcanic ash, and their lithological constitution, they cannot be derived from submarine flows of lava. They are rather incoherent volcanic products, or lapilli, the accumulations of which in the Pacific form a series of submarine tuffs.

One of the most remarkable facts, brought to light by these soundings in the Pacific, is the large share taken in the formation of these sedimentary deposits by palagonites, perfectly identical in lithological characters with those of Sicily, Iceland, and the Galapagos islands. Many are in fact glasses of the basic series, either consisting of sideromelane, or decomposed into a red resinoid substance. The small lapilli of two or three inches in diameter are cemented by zeolites, showing the crystalline forms of christianite.

The presence of these readily alterable basic glasses at once reveals the source of the clayey matter with which they are associated, as wherever rocks of this type occur, their decomposition into clay is observable.

Among the minerals present in the volcanic ash are rhombic tabular crystals of plagioclase, augite, magnetite, and a little sanidine or hornblende. It is singular that quartz-grains are practically absent, in striking contrast to coast deposits. This fact, however, is not so unexpected as the formation of zeolites in the free state. Minute fibrous radiated spherules are formed in the mud, possessing the crystallographic characters of christianite. Besides these zeolitic spherules, other crystals of the same kind occur in the form of minute prisms, and in such prodigious numbers that they make up about one third of the red clay. These and the zeolitic spherules are regarded by the authors as belonging to one mineral species, and they remark that the formation of these, and of the red clay in which they are developed, is easily understood if we bear in mind the lithological nature of the basic tuffs, and of their products of decomposition.—(*Nature*, September 18, 1879.)

Mud-Volcanoes.—Professor Gümbel of Munich has communicated to the Bavarian Academy (*Sitzungber.* 1879), a paper on mud-volcanoes and their products, his examination of which leads him to the following results. The mass of mud erupted is nothing but softened argillaceous, or sandy-argillaceous, stratified rock, derived from the immediate vicinity, and probably brought up from no great depth. It often contains organic remains, whilst true volcanic products (such as ashes, lapilli, lava, and pumice), take no part in its formation. It is only exceptional, if in the midst of volcanic formations the latter, softened superficially like the stratified rocks by gas and water, furnish the eruptive material, and indeed no such case is yet known with certainty.

Besides the abundant outflow of water, the efflux of gases at high pressure is necessarily and genetically connected with mud-volcanoes. Among these, carburetted hydrogen holds the first place. The high tension of the gases which flow out, and the long duration of the phenomena, do not infer the existence of a great accumulation low down in the earth, because upon such a supposition the provision must be exhausted in a comparatively short time. The persistent formation especially of the carburetted hydrogen, the principal of these eruptive gases, necessarily presupposes the presence of organic constituents in the deeper seated stratified rocks, and this is also confirmed by the regular occurrence of petroleum, naphtha, asphalte, or bituminous materials in connection with mud-volcanoes. It is not improbable that phosphuretted hydrogen is also produced during this process of decomposition, and the presence of this gas would furnish a satisfactory explanation of the frequent spontaneous ignition of the outflowing gases. On the other hand, the more abundant occurrence of carbonic acid would seem to indicate a certain approach to volcanic processes.

The intermixture of soluble salts, especially chloride of sodium, in the mass of mud, may be explained in part by the circumstance that many mud-volcanoes are situated in the vicinity of the sea, or upon a soil soaked with sea water. In favour of this, we have the presence of iodine and bromine in the mass of salts produced. It may also be assumed that the strata contiguous to the channel of eruption may contain abundantly such

salts as gypsum and rock salt, from which the outflowing water extracts its saline contents. Or the saline constituents may be dissolved from other strata by the water before reaching the mud-volcanoes, and left behind in the dry mud, upon the evaporation of the water.

The mode of distribution of mud-volcanoes shows a certain general relation to volcanic regions, and volcanic eruptions. They are, however, found in countries at present unaffected by volcanic phenomena, but in this case they either occur in districts which are frequently disturbed by upheavals and sinkings, or are confined to tracts of great geotectonic fissures and lines of displacement, which traverse the crust of the earth, and lead down to great depths.

From all these facts Professor Gümbel thinks it follows that the true focus of the phenomena connected with by far the greater number of mud-volcanoes cannot be directly identified with that of the volcanic activity of the depths of the earth, but that these phenomena are due rather to the presence of certain stratified rocks, and to their containing intermixtures capable of furnishing bituminous substances. In isolated cases it may be that gases connected with volcanic processes produce phenomena similar to those of ordinary mud-volcanoes, or associate themselves with the carburetted hydrogen gases of the true mud-volcanoes, just as, *vice versâ*, the latter gases frequently appear among volcanic exhalations. The stratified rocks involved in the process, must be situated deep in the earth's crust, where the conditions (warmth, &c.) necessary for the evolution of the gases and bituminous materials from the organic intermixtures are present, and at the same time the crust of the earth is traversed by fissures deep enough to enable the volatile materials thus formed under pressure to make their way to the surface. Such favourable conditions will occur most frequently where the younger sedimentary formations are deeply buried, and traversed by deep fissures by volcanic action. In this way we see how the phenomena of mud-volcanoes are distantly connected with true volcanic activity. In other cases, volcanic action may as, it were, have carried the conditions of formation of the eruptive gases and bituminous substances nearer to the surface, and into the higher beds of the sedimentary rock. Such a relation between mud-volcanoes and vulcanicity may be assumed especially in Sicily. Nevertheless, the phenomena of the so-called mud-volcanoes are so fundamentally distinct from those of true vulcanicity, that it seems desirable to get rid of the connection, apparently implied by the name, by the employment of a new term, such as "mud-springs" (*Schlammsprudel*).

Palæocoryne. Mr. G. R. Vine read a communication before the Geological Section of the British Association, in which, after referring to the great abundance of Carboniferous Polyzoa which have been discovered of late years, he gave the results of his researches upon the curious fossil bodies described by Professor Duncan and Mr. Jenkins, as probably fossil Hydroids, under the name of *Palæocoryne.* These supposed Hydroids have been regarded by some palæontologists, and notably by Dr. and Mr. Young of Glasgow, as mere appendages of Polyzoa. The author stated that he had identified all the species and forms of *Palæocoryne* that had been figured by Dr. Duncan in his various papers; but the conclusion he had arrived at was that these so-called organisms were neither hydroid, as was supposed by

Dr. Duncan, nor foraminiferal, as was suggested by Dr. Allman, but in all forms were referable to species of *Fenestella* and *Polypora*. Although this opinion was given with some confidence, the author was not prepared to say, at present, that the whole of Dr. Duncan's views were illusive. There could be no doubt but that the forms *P. scotica* were really infertile processes; but *P. radiata* had presented so many peculiar details to the author, that until he had satisfied himself as to the nature and purpose of this structure in the polyzoary of the Polyzoa, he was not in a position to prove that Dr. Duncan had given an erroneous judgment, although *P. radiata* might turn out to be, after all, a portion of *Fenestella* and not a parasite.

METEOROLOGY.

Rain and Temperature.—Mr. H. C. Fox, of Stoke Newington, read a paper before the British Association, at Sheffield, on the *Synchronism of mean temperature and rainfall in the climate of London.* The paper was accompanied by tables exhibiting each month and season for the past sixty-seven years, arranged in the order of its rainfall, and also in the order of its temperature, for the Royal Observatory.

The principal conclusions were stated to be:—

(1.) In each of the four months, from November to February, extreme cold tends to be synchronous with dryness, warmth with large rainfall.

(2.) In the summer months, from June to August, cold tends to be accompanied by much rain, warmth by dryness.

(3.) To put this in popular language, *rain brings warmth in winter and cold in summer*; that is (if rain be the cause, which is by no means proven), it mitigates the special character of each extreme season, winter and summer.

(4.) Very wet years tend to be either cold or warm, whilst years of drought tend to assume an average temperature.

MINERALOGY.

Mallardite and Luckite.—The name Mallardite has been given by A. Carnot to a new native manganese sulphate, and Luckite to a new native iron sulphate, which occur in the silver mine of Lucky Boy, at Utah (*Compt. rend.* 1879, lxxxviii. 1268). The former consists of small crystalline parallel fibrous masses, which are originally colourless and translucent, but on exposure to the air soon become white, and opaque, and weathered. It is easily soluble in water, and has the composition, $MnSO_4 + 7\,H_2O$. The sulphates already known are szmikite with one equivalent of water, fauserite with magnesia sulphate, and apjohnite with aluminium sulphate. The above may therefore be regarded as a new species. It is named Mallardite to honour M. Mallard of the *École des Mines.* The iron sulphate forms bright

bluish channelled prisms, and has the formula $(Fe,Mn)SO_4 + 7H_2O$, where the Mn is = about $\frac{1}{10}$ Fe. The mineral therefore stands between mallardite and melanterite. It weathers, but not in the air like the one, nor becomes of an ochre colour like the other. The crystalline form appears to be clinorhombic. It derives its name from the place where it is found.

On the Behaviour of Silicates containing Fluorine, especially the Topaz and the Micas, at High Temperature.—Rammalsberg has instituted a number of experiments expressedly with the view of determining the form in which fluorine is contained in the minerals in question, topaz and the micas. He finds that at the high temperature of the porcelain furnace, from topaz only could all the fluorine be removed under favourable circumstances. His experiments pointed to the probability that a part of the fluorine passes off in the free state; in other words, that in the presence of water vapour hydrogen fluoride was formed, while the elements united to the fluorine potassium, lithium, magnesium, iron, aluminium, silicium, remain as oxides, while another portion of the fluorine passes off in the form of a silicofluoride. This does not support the earlier view that silicium fluoride alone is evolved, and supports the theory of the author that fluorine is contained in these silicates in the same way as oxygen is. It appears, moreover, that, as a secondary action of the hydrogen fluoride, not only the fluorine present in the topaz in the form of aluminium silico-fluoride, but a certain amount of silicium of the oxysilicate, is converted into $SiFl_4$ and evaporates.—(*Wiedem. Ann.*, vii. 146.)

New American and Australian Minerals.—Under the name of Randite G. A. König, of Philadelphia, describes a new mineral, occurring on the granite in the neighbourhood of Philadelphia, in crusts, of a canary yellow to a citron yellow hue, which are transparent and apparently crystalline. It has a hardness of 2·3, and when heated in a closed tube evolves water, and acquires an orange red colour. Before being heated it is soluble in cold acid; after having been heated, it dissolves completely in hot acid only. 0·047 gramme of material collected for analysis had the composition:—

Lime	32·50
Uranium oxide	31·63
Water	6·53
Carbonic acid	[29·34]
	100·00

The formula derived from this, $Ca_5U_2C_6O_{20} + 3H_2O$, points to a relation existing between this mineral and liebigite. Before it can be determined whether a new species is actually present, it must be submitted to a more complete analysis. The name is chosen to honour Mr. Theod. Rand, of Philadelphia.—*Stibianite* is, according to E. Goldsmith, a new mineral from Victoria in Australia. It is massive, porous, has a reddish yellow colour, and a pale yellow streak, is dull, has a hardness of 5, and density of 3·67. An analysis made by W. H. Dougherty shows it to consist of—

Antimonic acid	81·21
Water	4.46
Insoluble portion	13·25
	99·22

which points to the formula Sb_2O_5, H_2O. So incomplete an analysis hardly justifies the giving a new name to the substance.—*Huntilith* is a new mineral, of which two varieties have been found. One is massive, has a dark slate gray or black colour, is dull, amorphous, porous, and friable; the other is apparently crystalline, shows a cleavage, a bright slate colour, and occurs in calc-spar, is half malleable, has a hardness of 2½. The density of the two varieties at 0° after impurities had been removed is, of the amorphous 7·47, for the crystalline 6·27. The chemical composition of the two sorts were found to be—

	I. Amorphous Variety.	II. Crystalline Variety.
Arsenic	21·10	23·99
Antimony	3·33	4·25
Sulphur	0·78	1·81
Mercury	1·04	1·11
Silver	59·00	44·67
Cobalt	3·92	7·33
Nickel	1·96	2·11
Iron	3·06	8·53
Zinc	2·42	3·05
Water	0·19	0·33
Gangue (silicate)	0·88	0·55
Do. (calcite)	2·35	1·10
	100·03	98·83

If the mercury be present as amalgam, Ag_2Hg, and the sulphur as pyrites as is most probably the case, and the Co, Ni, M, and the remaining Fe be reckoned with the Ag, making $R'' = 2R'$, we have in

I. $R' : As + Sb$ as 319 : 110 or as 2·90 : 1.
II. $R' : As + Sb$ as 332·5 : 110 or as 2·99 : 1.

Hence the mineral has the formula, Ag_3As, and may be regarded as an arsenic dyscrasite or a silver domeykite. This huntilith is found in large quantities in the Silver Islet Mine of Lake Superior, and is named to honour Dr. Sterry Hunt.—(*Zeitschrift für Kryst. und Mineralogie*, 1879, iii. 596–600.)

Swedish Minerals.—Blomstrand in a recent letter to the *Ber. deut. chem. Gesellschaft*, 1879, xii., 1723, communicates a few notes on recent researches on Swedish mineralogy. Hjalmar Sjögren describes native bismuth, associated with galena and pyrites, from Norberg's mine in Wermland.. Bjelkite is the name given to a mineral species having the formula $2PbS,Bi_2S_3$. The older analyses of this mineral by Lundström have led him to adopt the formula $(FeS, 2PbS)_3\ Bi_2S_3$. A new bismuth sulpho-salt, *galenobismutite*, has the formula, PbS,Bi_2S_3, and occurs in compact, tin-white particles. Anton Sjögren has published a paper on the occurrence of manganese compounds in the Nordmarks mine in Wermland. It treats of the very interesting gangue-like formation, distinguished for the manganese compounds which it contains, met with first in Langbans mine, and now hit upon in Nordmarks since. The ground mass is manganesiferous calcspar, which contains manganosite (the formula being MnO) in well-developed

microscopic crystals in the same form, belonging to the regular system, as the periclase of Vesuvius, pyrochroite (MnO,H_2O), also crystallized, hausmannite, manganese spar, brusite, heavy spar, as well as hornblende and granite. T. Nordström publishes an analysis of vanadinite, now for the first time found in Sweden from the Undenäs (manganese) mine in West Gothland, and a mineral containing 5 per cent. of selenium from Fahlun. Selenium has been found in the sulphuric acid mud of Fahlun; but minerals containing this substance are very rare. G. Lindström describes *Thaumasite*, a new mineral species from Åreskutan in Jemtland, which has the following curious composition—

$$CaO,SiO_2 + CaO,CO_2 + CaO,SO_3 + 14H_2O.$$

Great Meteorite in Iowa.—Professor Peckham, in a letter to the editor of "Silliman's Journal" (July, 1879, p. 77), gives an account of the fall of a meteorite at 5 P.M., on May 10, at Estermills, Emmet County, Iowa. One fragment, weighing almost 500 pounds, fell on railroad land and buried itself 14 feet in stiff clay soil. Another portion, of about 170 pounds, fell on a farm at a distance of about two miles from the above. Smaller pieces, from a few ounces to several pounds in weight, were scattered in the vicinity. The fall was accompanied by a noise described as a continuous roll of thunder, associated with a crackling sound. The smaller fragment above mentioned is of an irregularly quadrate form, measuring about 15×18 inches, and 6 inches thick on an average. The metallic portion consists of an alloy of iron, nickel, and tin. A small piece of the metal polished and etched showed the Widmanstättian figures very finely. Half the mass is stony matter, consisting of dark green crystalline masses, imbedded in a light grey matrix. When the whole is powdered, a violent reaction ensues on the addition of hydrochloric acid, and this is increased by boiling, when all but the grey matrix is dissolved. Under the microscope in thin sections, olivine and a triclinic felspar appear to be imbedded in a matrix of pyroxene.

PHYSICS.

Absorption of Ultra-Violet Radiations by the Atmosphere.—M. Cornu read a paper on this subject before the Academy of Sciences in June. He showed that the probability of the solar spectrum extending beyond what can now be seen, is evidenced by its abrupt and sudden termination in photographs of the most refrangible end, as compared with the spectrum of iron vapour. He demonstrated the atmospheric absorption by introducing a tube 4 metres long, closed at the ends with fluor spar, between the collimator and prism. When the tube was full of air, line 32 of the Aluminium spectrum is not visible, but as a vacuum is produced, the line appears.

The Friction of Fluids.—Professor Unwin, of Cooper's Hill College, recently read a paper on this subject before the Physical Society. He premised that it had long been known that a board, dragged through water, suffers a resistance varying in some way as the square of the velocity; that a stream

moves uniformly at such a speed that the component of water-weight down the inclined bed is balanced by frictional drag on the bottom. The fluid in the neighbourhood of the stream is known not to move as a solid mass, the centre moving faster than the sides, and the different fluid layers rubbing against one another. The adhesion of the fluid to the solid against which it moves, also gives rise to sliding or rubbing action. It is desirable to have a set of experiments in which the conditions can be varied more than can be done by such methods. He thought it instructive to try a limited mass of water, and a virtually unlimited surface, such as is given by a disk in rotation. This apparatus he had constructed. Within the outer vessel is placed a thin copper chamber, the diameter of which is unalterable, but the depth variable at pleasure. The disk is placed concentrically within it; so that there are two cheese-shaped masses of water, one above, one below the disk, which are dragged into rotation on the side next to it, and retarded next the sides of the pan. The couple required to rotate the disks is equal to that formed by the disk or fluid when the motion is uniform. Hence the tendency of the chamber to rotate is measured by suspending it from a trifilar suspension. A weight suspended by a cord measures the force required to keep the index at zero. It appears that a rough cast iron disk has a frictional resistance almost exactly as the square of velocity; whereas a turned brass disk gives a value of x decidedly less than 2. The resistance is a little greater when the mass of water is larger. He proposes to try the effect of temperature on fluid friction in viscous as well as in mobile fluids.

Specific Magnetism of Iron—forms the subject of an essay by Dr. Auerbach of Breslau. He shows that this is not without influence on the galvanic behaviour of the metal. If a current be conducted through an iron wire, phenomena appear which do not occur with other metals. The following are some of the known facts:—

(1.) The actual galvanic conductivity has been very variously stated, between 12·35, and 15·9 per cent.

(2.) Resistance increases with rise of temperature.

(3.) The heat generated by the current, by Joule's law, is 448·0 as against 478·9 for copper.

(4.) On closing the circuit, an extra current takes place in the opposite direction; on opening, in the same direction.

(5.) Longitudinal magnetization of iron influences its resistance.

In examining the last (5) phenomenon, the great difficulty was to exclude the influence of temperature. An adiathermanous magnetizing apparatus was made by winding the copper on a wide glass tube, into which a caoutchouc tube was introduced, with a smaller glass tube within it; the wire itself being wrapped in paper.

Special arrangements were made also to reduce the intensity of (4) the extra current.

These due precautions having been observed, a large transient diminution of resistance, and a smaller permanent diminution, were observed, the former amounting to 2 per cent.

A New Form of Spectrometer—is described by Dr. J. W. Draper, differing from the ordinary spectroscope, in the fact that whereas that deals with wave-

lengths and frequency of vibrations, this measures amplitudes on the intensity and brilliancy of light. It depends on the optical principle that light becomes invisible when in the presence of light sixty-four times more brilliant.

His mode of operating is as follows:—

Remove from the common three-tubed spectroscope its scale tube, and place against the aperture into which it was screwed a piece of glass ground on both sides. In front of this arrange an ordinary gaslight attached to a flexible tube, so that its distance from the ground glass may be varied at pleasure. On looking through the telescope, the field of view is seen uniformly illuminated, the brilliancy depending on the distance of the gaslight, according to the ordinary photometric law. This is called the extinguishing light. If it be put out for a moment, and the luminous flame of the Bunsen burner so arranged that its spectrum is seen, on relighting it a spectrum is seen in the midst of a field of light, the brilliancy of which can be varied at pleasure. As the intensity of the latter is increased, the violet first disappears, then the other more refrangible colours in their descending order, till at length the red alone remains. The yellow never stands out conspicuously, as might have been expected. This is scarcely consistent with the opinion that the yellow is the brightest of the rays. Dr. Draper, therefore, thinks that the luminous intensity of the coloured spaces has a relation to the compression or condensation that the prism is impressing upon them. To diminish the intensity of the extinguishing light, an exceedingly thin film of silver was deposited on the face of the prism which acts as reflector. This, though quite transparent to the transmitted rays, increased by metallic reflection the extinguishing rays.

The same estimate was made more simply with sunlight, by introducing a beam from a Heliostat, and throwing its spectrum on a screen. The window-shutters were then more or less opened to admit ordinary light. When the shutters were wide open, the spectrum was quite obliterated; on gradually closing them, the red region first came into view, the other colours following in order of refrangibility. Irrationality of dispersion in various kinds of glass did not seem perceptibly to influence the results, nor did differences in the eyes, the age, or the visual powers of different observers.

Dr. Draper saw at once in the dispersion-spectrum a means of testing his views as above stated. Using a grating, and the spectrum of the first order, as the force of the extinguishing illumination increased, all the coloured spaces yielded equally and simultaneously, re-appearing in a similar manner. The same happened with solar as with gaslight.

Light from Thermo-Electricity.—M. Clamond appears to have overcome the difficulty of producing a battery of this nature fit to produce the electric light. It is formed of iron as the electro-positive element, and of an alloy of antimony and zinc for the negative. They are arranged in a circular form, heated in the interior. The latest form consists of a number of pieces of cast iron, named the *collector*, so arranged that heated air can circulate between them. A large surface is thus exposed to the heat, which the iron collects, and communicates to the couples. The *Diffuser* is the outside of the apparatus, and is made of sheets of metal. The thermopile itself is placed between these two, and is so arranged that the junctions of the

metals are alternately at the temperature of the collector and of the diffuser. The pattern now in use for lighting a workshop in Paris is $2\frac{1}{2}$ metres high, and 1 metre in diameter. Another model, made for the exhibition at the Albert Hall, is square and smaller, though of the same power. Each half of the cylindrical battery can be made to supply a powerful electric light, while the square one can produce four lights of half the brilliancy. The electromotive force is, according to prolonged experiments, 218 Volts, about equal to 120 Bunsen cells, while the resistance is only ·31 Ohms. The large battery consumes 9 or 10 kilogrammes of coke an hour; the smaller, about $6\frac{1}{2}$ kilogrammes. The large external surface of the apparatus, radiating its heat to the air around, fits it for warming purposes as well as for lighting.

The Optical Structure of Ice has been investigated by Herr Klocke, who confirms the observation that the optic axis is at right angles to the surface whence the cooling proceeds. The ice flowers which first cover the sides of the vessel, however, have their principal axis parallel to these. The axis, according to M. Bertin, has a definite direction only after a fairly thick stratum of ice has been formed, the first layer being confused in its mode of crystallization; but Herr Klocke shows that the first needles shooting over the surface are formed parallel to the principal axis, and their ice plates are added to their sides, the optic axis of which is at right angles to the surface of the water.

The Temperature of Carbons giving the Electric Light has been examined by M. Rossetti, by means of a thermopile, the face of which is placed at a suitable distance to receive rays from a radiating surface of determinate size; the thermal effect being measured by a sensitive reflecting galvanometer. He comes to the conclusions that—(1.) The positive pole has higher temperature than the negative. (2.) The temperatures vary according to the intensity of the current. (3.) They are higher, the smaller the radiating surface, provided it comprises the extreme point. (4.) In the negative pole the minimum temperature was 1910° cent., with a large radiating surface of small brilliancy; the maximum 2532° cent., the radiating surface being half the preceding. (5.) For the positive pole the minimum temperature was 2312°, the carbon being large; the maximum 3200°, with a thin carbon and small radiating surface.

The Velocity of the Wind at Sea has been tested by Admiral Serres in the French Frigate *La Magicienne*, a Robinson anemometer being observed daily at a height of 8 metres, and twice daily at that of 36 metres, from the sea level. With very rare exceptions it was found much greater in the latter case than in the former, the average ratio being 12 to 10. Hence the modern practice of increasing the high sails at the expense of the lower is justified by observation.

A New Form of Leclanché Battery has been introduced by the inventor, in which the high resistance of the older pattern is diminished, and the employment of a porous pot is dispensed with. The carbon is surrounded with a mixture of 40 parts of pyrolasite, 155 parts of grain carbon, and 5 parts of resin, the latter acting as a cement. This composition is heated to 100° cent., and subjected to a pressure of 300 atmospheres. It forms a homogeneous cylinder, in the centre of which is the carbon electrode. The in-

ventor terms it the "conglomerate mixture" battery. The electromotive force is also higher than in the older form. He has also recently added depolarizing plates, which can be renewed from time to time. They are simply attached by indiarubber rings to the carbon.

It appears from careful experiments that the electromotive force of this arrangement is 1·46 of a Daniell element, and the resistance when new ·718 S.U. The electromotive force, however, diminishes rapidly when the external resistance is low, recovering quickly when the battery is at rest.

Electro-Optic Observations on Various Liquids form the subject of a paper by Dr. John Kerr, of Glasgow, following up his important observations in 1875 on a new relation between electricity and light. He then showed the possibility of inducing double refraction in glass, carbon disulphide, and several other dielectrics, by the application of electric force. He now furnishes notes of a later and more extended series of experiments on the same subject. The methods are substantially the same as before; but the means of observation have been greatly improved by assistance from the Government Fund. He uses a new plate cell, made of a block of selected plate glass, three-quarters of an inch thick and 8 inches long. Two fine holes are drilled right through it; one parallel, the other at right angles to its length, crossing in the centre, equidistant from the two faces of the plate. Two other holes are subsequently made through the plate; one a tunnel, 1 inch high and $\frac{5}{8}$ inch wide; the second, a slightly tapering hole, into which is fitted a glass stopcock, so as to open and close the vertical boring. The electric terminals within the tunnel are two balls of brass, a quarter of an inch in diameter. To these two brass rods pass from the ends of the block, being made water-tight at the outer ends by india-rubber washers. The brass balls are strongly electro-plated with silver, and turned in the lathe so as to present flattened spheroidal surfaces to each other, distant by one eighth of an inch from one another. The cell is closed at either end by panes of plate glass, $\frac{1}{16}$ inch thick and 2 inches square, with interposed sheets of india-rubber. The whole is supported by glass pillars, terminating in a solid wooden stand. All is then covered by a thick coat of shellac varnish.

The cell thus constructed is filled with the fluid to be examined by means of a small funnel drawn to a fine end.

It is often necessary to introduce definite and very faint birefringent actions between polarizer and analyzer. For this purpose, slips are cut out of plate glass, $\frac{1}{16}$ inch thick, $\frac{7}{8}$ inch wide, and 7 inches long. When such a strip is forcibly extended by means of a weight, it acts on the transmitted light as does a positive uniaxial crystal, with its axis along the line of tension; when compressed, as a negative of similar power and position. These are termed optical compensators, some of which are fixed and constantly stretched by weights below sixteen pounds; others are held in the hand, with their long axes inclined 45° to the plane of polarization.

The various pieces are arranged as follows:—The ray is horizontal, furnished by a flat paraffin flame placed edgeways, passing first through a polarizing Nicol's prism; then through the cell above described, the two terminals being connected, one with the prime conductor of an electrical machine, the other to earth. Then follow two compensating plates of glass, mounted vertically, so as to admit of the attachment of stretching weights

to either or to both. A third neutralizing plate is sometimes required in delicate observations. Lastly is an analyzing Nicol's prism.

The polarizer is first placed at 45° to the axis of the electric field, and the analyzer turned to complete extinction of the ray. The cell, with conducting wires, is now interposed, and the light restored by the use of a hand-compensator, forming a fine streak passing midway between the balls in the cell. The cell is then charged with clean liquid, and the electrical machine is set at work. If carbon disulphide, by far the best dielectric yet discovered, be employed, a slight movement of the machine restores the extinguished light in the polariscope. As potential rises, the light becomes quite brilliant; but on taking a spark from the prime-conductor, it vanishes instantly. There is no rotation of the plane of polarization, since slight contrary rotations of the analyzer affect the ray equally and similarly. Carbon disulphide appears to insulate completely, sparks drawn with the cell in circuit being of the same length as when it is removed. The action of dielectrified carbon bisulphide is therefore the same as that of glass extended in a direction parallel to the lines of force, and is a uniaxial birefringent action. Of the two component vibrations polarized in planes parallel and perpendicular to the lines of force, the latter is retarded. Weights are now attached to the compensating slips, causing strong permanent restoration from extinction of the light in the polariscope. If the machine be then worked, a broad horizontal band of darkness crosses the flame in the axis of the field, becoming by degrees perfectly black. With increased potential the flame reappears as a speck in the centre of the band, until the band is broken up into two on opposite sides of the axis, concave to one another. With rising potential, they move symmetrically outwards from the axis, dividing the flame into three large segments of equal brightness. When the electric action is near spark-discharge through the liquid, the bands cross the flame just outside the cylinder enveloping the two balls. This experiment represents the crossing of positive uniaxial plates. With a tension of 12 to 16 lbs., the bands are distinct, narrow, sharply defined, and very black.

Benzol, toluol, xylol, cumol, cymol, terebene, and amylene, were tried in the same manner, yielding similar results. Carbon dichloride stands somewhat above benzol. Nitrobenzol, tested in the usual way, acts as a good conductor, and gives no optical effect. If, however, the earth wire be disconnected, and a spark taken from it to the band at the instant of discharge, there is a strong restoration of light from extinction. The same effect occurs less distinctly with amylene.

Stannic chloride gave remarkable but not easily defined results. Young's paraffin oil gave fine effects, similar to carbon disulphide.

The fixed oils of olives, sweet almonds, poppy seed, rape seed, colza, mustard, linseed, nut oil, lard oil, and neatsfoot oil, acted oppositely to carbon disulphide. Animal oil, such as sperm, acted similarly to that substance, and in an opposite manner to every other fixed oil.

On the Capillary Phenomena of Jets is the title of a communication from Lord Rayleigh to the Royal Society. It is in a manner supplementary to a previous paper "On the Influence of Electricity on Colliding Water Drops," abstracted in our Summary of July. Water issuing from a circular orifice under pressure, though forming a contracted vein, remains circular. If the

orifice be not circular, the section of the jet undergoes remarkable transformations, the peculiarities of the orifice being inverted and exaggerated in the jet. With an elliptical orifice of which the major axis is horizontal, the jet becomes circular at 30 lines, the vertical axis then increasing till the vein spreads into a flat vertical sheet which preserves its continuity to 6 feet from the orifice. An orifice shaped as an equilateral triangle furnishes a jet composed of three flat sheets disposed symmetrically round the axis, their planes being perpendicular to the sides of the orifice. A vein issuing from a regular polygon of any number of sides resolves itself into an equal number of thin sheets, with planes perpendicular to the sides of the polygon. This extension of the sheets has, however, a limit, and sections taken at greater distances show gradual shortening, ending in a return to the form of the first contraction. Beyond this point sheets are again thrown out, again to return to the original figure. The explanation of the phenomenon seems to depend on capillary force. The fluid behaves as if enclosed in an envelope of constant tension, the recurrent forms of the jet being due to vibrations of the fluid column about the circular figure of equilibrium, superposed upon the general progressive motion. The distance between consecutive corresponding points of the recurrent figure, or as it may be called the *wave-length* of the figure, is directly proportional to the velocity of the jet, *i.e.* to the *square root* of the head of water. But little variation in the magnitudes of successive wave-lengths is to be noticed, even in the case of jets falling vertically with small initial velocity. In the experiments described, the jets issued horizontally from orifices in thin plates adapted to a large cistern.

Tables of seven sets of experiments follow, giving the observed wave-length and square root of pressure for different heads of water. At the higher pressures the observed wave-lengths have a marked tendency to increase more rapidly than the velocity of the jet. The orifices were rectangular, elliptical, triangular, and square. It was found that the value of λ depends on the nature of the fluid; methylated alcohol, for instance, gave a wave-length twice that of water. If a jet of mercury discharging into dilute sulphuric acid be polarized by an electric current, the change in the capillary constant, discovered by Lippmann, shows itself by alterations in the length of the wave. A mathematical investigation of the above facts follows. The flow of a vein from circular orifices is next adverted to, and its resolution from a cylinder into drops. This phenomenon is much influenced by vibration of the orifice under the impact of the jet, and when the disintegration of the jet establishes itself with complete regularity, it is attended by a musical note. The pitch of this, due to a jet of given diameter, issuing under a given head, enables the wave-length of the nascent divisions to be at once deduced. The most certain method of obtaining complete regularity of resolution is to bring the reservoir under the influence of an external vibrator, the pitch of which is approximately the same as that proper to the jet. Savart found that the note might be a fifth above, and more than an octave below that proper to the jet. An electrically maintained tuning-fork is perhaps the best apparatus for the purpose. In consequence of the rapid motion, some optical device is necessary to render apparent the phenomena attending the disintegration of the jet. The shadow of the jet thrown on a ground glass screen from the electric spark illumina-

tion is suggested; or the jet itself may be observed if illuminated by the same spark diffused by passing through ground glass. The electrically maintained fork may be made to perform the double office of controlling the resolution of the jet, and of interrupting the primary current of the coil. The jet then illuminated in only one phase appears perfectly steady, and may be examined at leisure. In an appendix to this powerful but graceful monograph, the mathematical investigation of the motion of frictionless fluid under the action of capillary force, in the form of an infinite circular cylinder, and the vibrations of a liquid mass about a spherical figure, is worked out at some length.

ZOOLOGY.

Morphology of the Nervous System in Dipterous Insects.—Mr. J. Künckel has lately communicated to the Academy of Sciences (*Comptes rendus*, 1 *September*, 1879) a summary of the results of his researches upon the nervous system in the Diptera. He finds that in the arrangement of the ganglia forming the central chain, there may be a close centralization or union of the whole into an almost continuous mass, or an extreme separation of the nervous centres, with the most various intermediate groupings; but, at the same time, each family has its nervous system constructed upon a peculiar and invariable plan. One of his most curious results, is the discovery that in certain groups, namely, the Stratiomyidæ, Tabanidæ, Syrphidæ, Conopidæ, and certain Muscidæ Acalypteræ, the ganglia which were originally united in the larva become separated during the passage of the insect into the pupa; so that instead of being shortened, as in many insects, by the approximation of the ganglia, and the fusion of some of them, in these flies the ganglionic chain is actually lengthened in the imago, and some of the ganglia are passed into the abdomen.

In accordance with the evolution of the nervous system, M. Künckel suggests that the Diptera may be divided into three groups:—1. Those which follow the ordinary law, and in which some of the ganglia become fused together during the passage to the pupa stage (the *Nemocera* of the older Entomologists):—2. Those in which the ganglia separate at the same epoch (the families above-mentioned):—and 3. Those in which the thoracic and abdominal ganglia remain confounded, as in the larvæ (Muscidæ Calypteræ, Œstridæ, Hippoboscidæ, Nycteribiidæ). In all Diptera the ganglia are distinct and clearly separated in the embryo. In the larvæ of the first group they remain distinct; in those of the two other divisions, they tend constantly to approach each other, their coalescence increasing with the growth of the larvæ. In the pupæ of the second group there is a phenomenon of reversion, the nervous centres again separating; whilst in the pupæ of the third group they remain associated in a single mass.

M. Künckel passes in review the families of Diptera, which, as he says, differ in the value of the external characters on which they are based, and indicates the following as approximately equivalent groups:—the Hippoboscidæ, Nycteribiidæ, Œstridæ, and Muscidæ Calypteræ, which have the thoracic and abdominal centres united into a single mass, may form a special

group; the Conopidæ, and the greater part of the Muscidæ Acalypteræ having one thoracic and one abdominal centre, may form a second; the Syrphidæ, with one thoracic and two abdominal centres constitute a third very natural group; the Tabanidæ and Stratiomyidæ, with one thoracic and five abdominal masses, a fourth; the Therevidæ, which have two thoracic and five abdominal centres, and the Scenopinidæ, with three thoracic and five abdominal masses, form parts of special groups; whilst a seventh section, having two or three thoracic centres, more or less confounded, and always six abdominal centres, includes the Xylophagidæ, Empidæ, Asilidæ, Bonbyliidæ, Bibionidæ, Culicidæ, Tipulidæ, &c. This proposed grouping will hardly be accepted by entomologists, although in some particulars it is very suggestive.

The Cephalic Ganglia of Insects.—M. N. Wagner describes the structure and functions of the ring of ganglia surrounding the œsophagus in insects (*Comptes rendus*, August 11, 1879). According to him the subœsophageal ganglion has nothing to do with the general co-ordination of the movements of the insect; it chiefly governs the organs of the mouth, and differs but little in its histological structure from the other knots of the ganglionic chain. The supra-œsophageal ganglia he regards as truly cerebral, and as the seat of nearly all the functions of the cerebral hemispheres of the vertebrata. Hence their structure is more complex, although they are constructed upon the same general plan as the other ganglia. In the middle they present bundles of nerve-fibres, whilst the nerve-cells chiefly occupy the periphery. Towards the centre of the ganglion there are three small groups of cells one above the other and communicating by numerous fibres. The foremost group has the closest relations with the convolutions (or horse-shoe bodies), which are particularly well-developed in the social Hymmoptera, the most intelligent of all insects, and the author states that the development of these parts is coincident with the intellectual development. Thus it is most remarkable in the worker ants and the worker bees, and less striking in the female ant and queen bee. These parts are rudimentary in the males. From the sides of the ganglia issue the lobes which go to the compound eyes. These are oval, and formed in the middle of short cylinders arranged in rows. These cylinders give origin to fibres which penetrate to the base of the brain. In the external part of the optic lobes these fibres intercross and present the form of two flattened cones with their apices turned towards each other. In this way the fibres of the left side appear on the right side, and the inferior fibres become superior, and each fibre by thus changing its direction enters into the constitution of the optic nerve which runs to each of the eyes forming together the compound eyes. This organization probably causes a perfect coincidence of all the optical impressions received by each eye.

Nerves of the Proboscis of Diptera.—M. Jules Künckel has examined into the terminations of the nerves in the proboscis of the Diptera (*Assoc. Franç. Avancem. des Sci.*, 1878, p. 771). He remarks that the proboscis terminates in two valves, which, in repose, are laid against each other, but during suction are applied to the surface attacked so as to constitute a regular sucking cup. These valves represent the labial palpi. Their internal structure presents a peculiarity well known to microscopists;

they contain a large tube, from which issue numerous branches in a digitate form, and all these parts present an appearance like that of tracheæ. The name of *false-tracheæ* which has been given to them is perfectly justified, as they have no communication with the true tracheary apparatus, their principal function being to support the integuments of the palpi, whilst a true trachea ramifies in these organs. Parallel to the large trunk of the false-tracheæ the labial nerve may be traced, of comparatively large size. It speedily divides into two parts, and emits a multitude of ramifications to the periphery and inner surface of the valves. Those nervous filaments which run to the periphery go to the numerous and greatly developed hairs with which the margin of the valve is furnished; those which go to the inner surface on the contrary terminate at rudimentary hairs, reduced to a minute chitinous cylinder.

On examining the nervous terminations which run to the marginal hairs, it will be found that a filament separates from the ganglionic inflation, and goes to the hair, as has been already described and figured by M. Jobert, but that it terminates in the interior of the hair at the point where the latter is joined to the integument by a membranous part. On the other hand, in the case of the terminations which go to the rudimentary hairs, the filament will be seen to traverse the little cylinder and project outside in the form of any fine and delicate rounded point. There are thus in the proboscides of the Diptera (Muscidæ and Syrphidæ) two kinds of nervous terminations—one set connected with well-developed hairs, which are no doubt tactile in function; the other with rudimentary hairs of peculiar form, which are probably gustative.

The Vertebrate Skeleton.—M. Sabatier has propounded certain views as to the nature of the Vertebrate Skeleton which are slightly at variance with generally-received opinions, although we fancy that something analogous has already been suggested more than once. M. Sabatier denies the existence of the vertebral type, and regards the vertebra as nothing but the solidification of an intermuscular axis of connective tissue, the appendages of which are contingent and depend on the development and arrangement of the muscular system. Leaving out of consideration the cranium, the vertebral composition of which he regards as untenable in face of embryological data, M. Sabatier remarks with regard to the rest of the vertebral column:—

1. That the points of ossification are extremely variable as to number and position from one moment to another.

2. That the typical parts of the vertebra are often deficient, as, for example, the centrum, which is sometimes only an appendage of the neurapophyses.

3. That the parts of the vertebra are sometimes autogenous, sometimes heterogenous.

4. That the caudal ribs or hæmal arches of the tail in fishes completely change their signification, according as we have to do with osseous fishes, in which they are formed by the paraphyses, or with cartilaginous fishes, in which they represent true ribs.

5. That the lateral apophyses of the body of the vertebra are multiplied where the muscular system is complicated. Thus the four lateral apophyses of the lumbar vertebræ of the dog and of the large carnivora originate from

the expansion of a single tubercle of the dorsal vertebræ, because the sacro-lumbar muscles acquire great complexity and multiply their tendons at the level of the loins.

Hence M. Sabatier concludes that the vertebral type composed of necessary elements does not really exist, and that the apophysary elements of the vertebra are produced by the constitution of the muscular system.—(*Assoc. Franç. Avancem. Sci.*, 1878, p. 773.)

Hedgehog and Viper.—The common Hedgehog is generally described as a mortal enemy to snakes of all kinds, and it has been supposed that he enjoys an immunity from the effects of the bites of the venomous species. M. Samie with a circumstantiality which reminds one of the reports of prize-fights in "Bell's Life" during the palmy days of the ring, relates all the particulars of a combat which he excited between a Hedgehog and a Viper (*Vipera aspis*). The Hedgehog attacked the snake as soon as he was aware of its presence, seizing it in the first place at the hinder part of the body, and continuing his assaults until his formidable enemy was reduced to a helpless state, when he commenced eating it at the tail end; afterwards, proceeding to the head, he carefully detached and devoured the *lower jaw*. The Viper was still alive. The most interesting point brought out by this experiment of M. Samie's is the mode in which the Hedgehog defended himself against the dangerous weapons possessed by his adversary. When bitten, the Viper at first turned to strike its assailant, when the Hedgehog immediately drew forward over his head that mass of spines which forms the front part of his defences; and when the snake struck open-mouthed at its persecutor, its attack was foiled by this formidable *cheval-de-frise*. Several times the same manœuvre was repeated, until the snake's mouth was so severely lacerated that it no longer attempted to use its fangs, but sought safety in vain in flight. The Hedgehog frequently rolled himself up for a time after having made an attack upon his victim. M. Samie's results are interesting, but it is clear that he has not the fear of antivivisectionists before his eyes.—(*Actes Soc. Linn. de Bordeaux*, 1878, p. 257.)

Habits of Sphenodon (Hatteria).—Dr. W. L. Buller has communicated to the New Zealand Institute some observations relating to the habits and especially the food of the curious Lizards forming the genus *Sphenodon* (or *Hatteria*), two of which (*S. punctatus* and *S. Güntheri*) are now known to inhabit New Zealand. In captivity his specimens ate nothing for a considerable time, but on the approach of summer they fed freely, evincing a preference for flies and *Cicadæ*. Of the latter they sometimes devoured fifty in a day. They also fed freely on earthworms. After various vicissitudes including a period of violent cannibalism, it was accidentally found that they devoured small sea fishes three or four inches long with great avidity, a circumstance which, considering their general unwillingness to feed except on what may be regarded as their natural food, would lead one to suppose that small fish ordinarily form part of the diet of the Sphenodons. This would account for their fondness for water, in which they pass much of their time, and Dr. Buller found that they took to sea-water quite as readily as to fresh. He thinks that in their wild state they are probably amphibious.—(*Trans. New Zealand Inst.*, vol. xi. p. 349.)

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